DEFENSE AR JOURNAL

Defense Acquisition Research Journal

A Publication of the Defense Acquisition University

Thinking for Ourselves:

Understanding Best Practices to Work Smarter

Defense Acquisition University

July 2013 Vol. 20 No. 2

ISSUE 66

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JUL 2013**	2. REPORT TYPE	3. DATES COVERED
4. TITLE AND SUBTITLE **Thinking for Ourselves:Understanding Best Practices to Work Smarter**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defense Acquisition Research Journal,Attn: DAU Press,9820 Belvoir Rd. Ste 3,Fort Belvoir,VA,22060**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**259**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

DEFENSE AR JOURNAL

Defense Acquisition Research Journal

A Publication of the Defense Acquisition University

We're on the Web at:

http://www.dau.mil/pubscats/Pages/ARJ.aspx

Defense Acquisition University

ISSN 2156-8391 (print) ISSN 2156-8405 (online)

The *Defense Acquisition Research Journal,* formerly the *Defense Acquisition Review Journal*, is published quarterly by the Defense Acquisition University (DAU) Press. Postage is paid at the U.S. Postal facility, Fort Belvoir, VA, and at additional U.S. Postal facilities. Postmaster, send address changes to: Editor, *Defense Acquisition Research Journal,* DAU Press, 9820 Belvoir Road, Suite 3, Fort Belvoir, VA 22060-5565. Some photos appearing in this publication may be digitally enhanced.

DEFENSE ARJ JOURNAL

A Publication of the Defense Acquisition University

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Current Barriers to Successful Implementation of FIST Principles

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Capt Brandon Keller, USAF, and Lt Col J. Robert Wirthlin, USAF

The Fast, Inexpensive, Simple, and Tiny (FIST) framework proposes a broad set of organizational values, but provides limited guidance on practical implementation. Implementing FIST principles requires clarifying the definitions of "fast," "inexpensive," and "simple," recognizing where FIST does and does not apply. Additionally, a subset of the FIST heuristics was expanded upon to increase their usefulness for practitioners. The primary research findings are that FIST principles are less conducive for highly complex or novel systems, immature technologies, future needs, acquisitions in early development phases, or when performance is the foremost value. FIST principles were also found to be constrained by the acquisition process, the requirements process, and oversight.

Defense Logistics Agency Disposition Services as a Supply Source: A DoD-Wide Opportunity

p. 218

Capt Nate Leon, USMC, Capt Todd Paulson, USMC, and Geraldo Ferrer

The Defense Logistics Agency Disposition Services (DDS) provide centralized disposal management of excess and surplus military property. An important component of its mission is the *reutilization* of excess equipment within the military services to prevent wasteful purchases within the Department of Defense. This research analyzes the extent to which the U.S. Marine Corps (USMC) is implementing reutilization through DDS as a source of supply. The results and recommendations of this study will enable decision makers within the USMC and the Defense Logistics Agency to address institutional and systemic obstacles to maximize reutilization. Some of the lessons learned herein may be useful to all the military services, resulting in more value from their operations and maintenance budgets through reutilization.

CONTENTS | Featured Research

From the Deputy Executive Editor

The articles included in this month's issue suggest a time-honored maxim that is consistent with the philosophy and guidelines espoused by Under Secretary of Defense for Acquisition, Technology and Logistics Frank Kendall (2013) in a recent memorandum. The maxim is *Caveat Emptor*—Let the buyer beware! One reasonably might ask: How does that maxim relate to Mr. Kendall's memorandum, or to the articles in this issue?

In the commercial world, *caveat emptor* means that the buyer bears the risk for the quality of goods purchased unless they are covered by the seller's warranty. A standard commercial principle is that product use other than for intended purposes may void any manufacturer's warranties. Extending that principle, acquisition managers inadvertently may negate anticipated benefits of best practices if they fail to thoughtfully and deliberately analyze their appropriateness to the context and conditions under which they are to be applied.

Mr. Kendall emphasized that key enduring acquisition principles and evolving best practices work when they are applied effectively with a thorough understanding of the program context and an understanding of the risks. He stressed the need to "apply our education, training, and experience through analysis and creative, informed thought" to program decisions (Kendall, 2013, p. 1). His principal guideline was succinct: *Think*.

In our first article, RAND coauthors (Blickstein, Nemfakos, and Sollinger) shared lessons learned from their analyses of nine major defense acquisition programs that experienced Nunn-McCurdy breaches. Their analyses provided insight into the breaches and some lessons for how other programs can avoid them. The authors also note that every program is different, and they caution that managers should be wary of applying policies founded on the premise that all program cost increases stem from common causes.

Coauthors from Lockheed Martin (Eiband) and The George Washington University (Eveleigh, Holzer, and Sarkani) examined reuse of legacy systems as an "oft-touted" approach to achieve affordability and reduce acquisition timeframes. Failure to analyze the implications of reuse may result in adverse cost, schedule, and system performance outcomes. The authors developed a Reuse Evaluation Framework to aid program planners identifying opportunities for reuse that offer the greatest chance of success.

Coauthors from the Institute for Defense Analyses (Arnold, Harmon, Rose, and Whitley) discussed the need for adjusting target fees when using Economic Price Adjustment (EPA) clauses in contracts. They noted that EPA clauses can entail unintended risks and drive unwanted behavior; assessing those risks and behavior motivations requires in-depth assessment of the specific contract and the contractor.

Similarly, coauthors from the Air Force Institute of Technology (Keller and Wirthlin) examined the Fast, Inexpensive, Simple, and Tiny (FIST) principles touted in various circles as a means to reforming acquisition. The authors offered their own planning considerations to augment the FIST heuristics and identified barriers and limitations to successful implementation of the concept.

Finally, authors from the Marine Corps Logistics Base Albany, GA, Defense Language Institute, and Naval Postgraduate School (Leon, Paulson, and Ferrer, respectively) explored the extent to which equipment reutilization can achieve cost savings from wasteful, duplicative purchases—savings that can be used to cover other shortfalls in a dwindling defense budget. Ironically, one obstacle that potentially prevents managers from aggressively seeking those savings is the DoD culture, implying that managers must constantly examine and challenge patterns of shared, basic assumptions about their business.

These articles represent research results from a variety of organizations and perspectives. I hope that you will enjoy them and can use the information they contain to inform your selection of best practices. Enjoy!

Dr. Mary C. Redshaw
Deputy Executive Editor
Defense ARJ

Reference

Kendall, F. (2013, April 24). *Implementation directive for Better Buying Power 2.0—Achieving greater efficiency and productivity in defense spending* [Memorandum]. Washington, DC: Office of the Under Secretary of Defense (Acquisition, Technology and Logistics).

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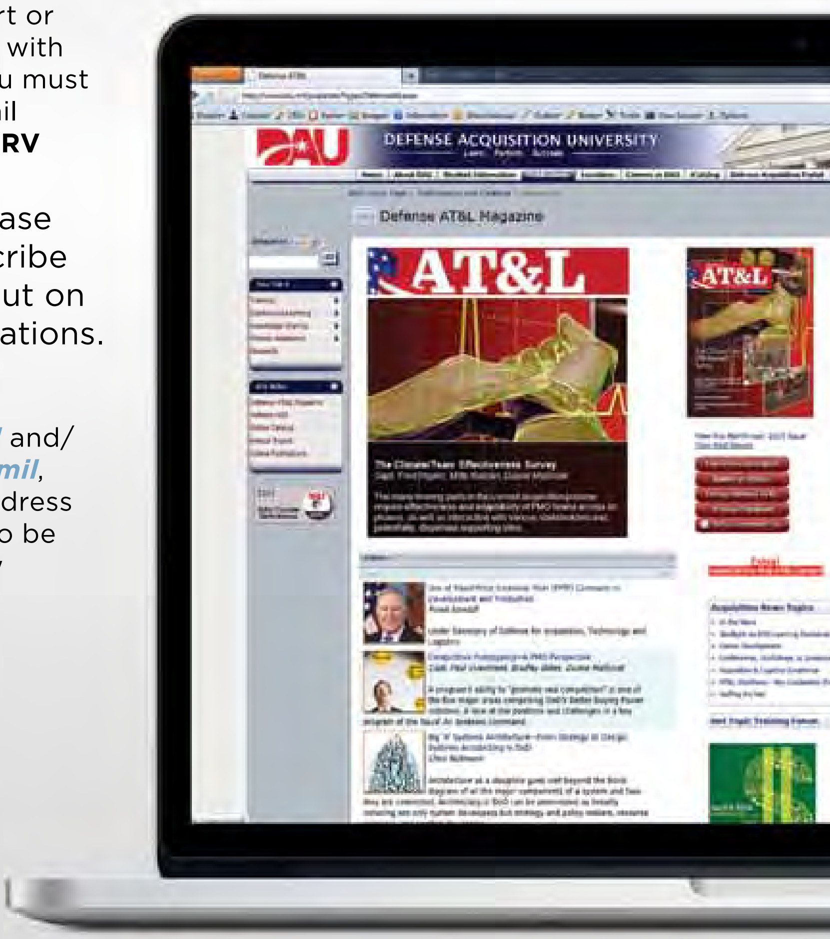


DAU Center for Defense Acquisition Research

Research Agenda 2013

The Defense Acquisition Research Agenda is intended to make researchers aware of the topics that are, or should be, of particular concern to the broader defense acquisition community throughout the government, academic, and industrial sectors. The purpose of conducting research in these areas is to provide solid, empirically based findings to create a broad body of knowledge that can inform the development of policies, procedures, and processes in defense acquisition, and to help shape the thought leadership for the acquisition community.

Each issue of the *Defense ARJ* will include a different selection of research topics from the overall agenda, which is at: http://www.dau.mil/research/Pages/researchareas.aspx

Affordability and cost growth

- Define or bound "affordability" in the defense portfolio. What is it? How will we know if something is affordable or unaffordable?

- What means are there (or can be developed) to measure, manage, and control "affordability" at the program office level? At the industry level? How do we determine their effectiveness?

- What means are there (or can be developed) to measure, manage, and control "Should Cost" estimates at the Service, Component, program executive, program office, and industry levels? How do we determine their effectiveness?

- What means are there (or can be developed) to evaluate and compare incentives for achieving "Should Cost" at the Service, Component, program executive, program office, and industry levels?

- Recent acquisition studies have noted the vast number of programs and projects that do not make it successfully through the acquisition system and are subsequently cancelled. What would systematic root cause analyses reveal about the underlying reasons, whether and how these cancellations are detrimental, and what acquisition leaders might do to rectify problems?

- Do Joint programs—at the inter-Service and international levels—result in cost growth or cost savings compared with single-Service (or single-nation) acquisition? What are the specific mechanisms for cost savings or growth at each stage of acquisition? Do the data support "jointness" across the board, or only at specific stages of a program, e.g., only at research and development or only with specific aspects, e.g., critical systems or logistics?

- Can we compare systems with significantly increased capability developed in the commercial market to DoD-developed systems of similar characteristics?

- Is there a misalignment between industry and the government priorities that causes the cost of such systems to grow significantly faster than inflation?

- If so, can we identify why this misalignment arises? What relationship (if any) does it have to industry's required focus on shareholder value and/or profit, versus the government's charter to deliver specific capabilities for the least total ownership costs?

DEFENSE ***ACQUISITION RESEARCH*** JOURNAL

ISSUE 66 JULY 2013 VOL. 20 NO. 2

Keywords: *Nunn-McCurdy Breaches, Defense Acquisition Cost Growth, Selected Acquisition Report (SAR), Wideband Global Satellite (WGS), Performance Assessments and Root Cause Analyses (PARCA)*

Digging Out the Root Cause: *Nunn-McCurdy Breaches in Major Defense Acquisition Programs*

Irv Blickstein, Charles Nemfakos, and Jerry M. Sollinger

Continuing concern over defense acquisition has led Congress to direct the establishment of an office in the Department of Defense to oversee the conduct of root cause analyses on programs that have incurred Nunn-McCurdy breaches. Analyses of six programs that have incurred such breaches reveal that many of the causes of the breaches are common to several programs. However, each program is different, and those differences suggest that policymakers should be wary of applying policies that assume all program cost increases stem from common causes.

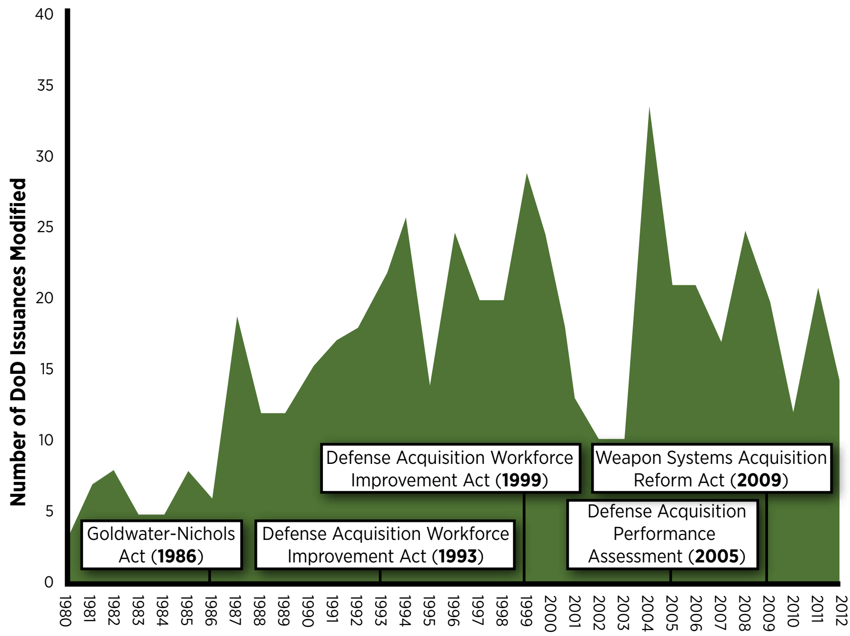
Image designed by Diane Fleischer »

Congress has long been concerned about cost overruns in Major Defense Acquisition Programs (MDAPs). Beginning in the 1970s when it expropriated the Selected Acquisition Report (SAR) as a gauge of program performance, Congress has continued to create mechanisms to gain insights into program execution.[1] However, SARs did not become a legal reporting requirement until 1975, with Public Law (Pub. L.) 94-105 (Leach, 2003). In 1981, Senator Samuel Nunn and Congressman David McCurdy introduced the Nunn-McCurdy Amendment to the Department of Defense Authorization Act, 1982 (Pub. L. 97-86, 1981). The purpose of the amendment was to establish congressional oversight of defense weapon systems acquisition programs whose costs rise above certain limits. The Nunn-McCurdy Amendment defines two types of unit cost. The first is total program acquisition unit cost (PAUC), which is the sum of development cost, procurement cost, and system-specific military construction for the acquisition program, divided by the number of fully configured end-items to be produced for the acquisition program. The second is average procurement unit cost (APUC), which is the procurement funding divided by the number of units procured. Cost growth of a weapon system was measured by how much the unit costs in 1982 exceeded the same respective unit costs reported in the weapon system's SAR dated March 31, 1981. Hence, the amendment applied only to those major weapon systems reported in SARs dated March 31, 1981. The original amendment required the Secretary of Defense to notify Congress when a major weapon system's unit cost growth exceeded 15 percent. If unit cost growth exceeded 25 percent, the program was assumed terminated unless the Secretary of Defense submitted written certifications to Congress within 60 days of determining that a breach had occurred. The provisions were made permanent in the Department of Defense Authorization Act, 1983, and these breaches are commonly referred to as Nunn-McCurdy breaches.

Over time, the Department of Defense (DoD) leadership promulgated many external as well as internal initiatives to reform the acquisition system. Figure 1 captures the DoD Issuances as well as a few of the major initiatives pushed by Congress and by the DoD leadership, where the acquisition system has been the prime focus. Clearly, over time these efforts for reform have increased.

The National Defense Authorization Act for Fiscal Year 2006 changed the Nunn-McCurdy reporting requirements to include the original baseline as a benchmark against which to measure cost growth.

FIGURE 1. DoD ISSUANCES AND REFORM OVER TIME



The Weapon Systems Acquisition Reform Act (WSARA) of 2009 is the latest effort, and it incorporates definitions for two categories of weapon system breaches: significant and critical (Pub. L. 111-23, 2009). A breach is determined by comparing original and current PAUC and APUCs, and a breach can occur if the unit costs exceed either the current or the original baseline by a specific percent. Thresholds appear in Table 1.

The National Defense Authorization Act for Fiscal Year 2006 changed the Nunn-McCurdy reporting requirements to include the original baseline as a benchmark against which to measure cost growth.

Congressional interest in, and efforts to contain spending on, defense acquisition have continued (Government Accountability Office, 2011). The Weapon Systems Acquisition Reform Act (WSARA) of 2009 established a number of requirements that affected the operation of the Defense Acquisition System and the duties of the key officials who

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TABLE 1. BREACH THRESHOLDS

Level	Unit Cost	Baseline	Threshold
Significant	PAUC	Current	>=15%
	APUC	Current	>=15%
	PAUC	Original	>=30%
	APUC	Original	>=30%
Critical	PAUC	Current	>=25%
	APUC	Current	>=25%
	PAUC	Original	>=50%
	APUC	Original	>=50%

support it, including the requirement to establish a new organization in the Office of the Secretary of Defense (OSD) with the mandate to conduct and oversee Performance Assessments and Root Cause Analyses (PARCA) for MDAP (Pub. L. 111-23, 2009).

Pub. L. 111-23 assigned the resultant PARCA organization five primary responsibilities:

1. Carrying out performance assessments of MDAPs;

2. Performing root cause analysis (RCA) of MDAPs whose cost growth exceeds the threshold as detailed in the Nunn-McCurdy provision;

3. Issuing policies, procedures, and guidance governing the conduct of performance assessments and RCAs;

4. Evaluating the utility of performance metrics used to measure the cost, schedule, and performance of MDAPs; and

5. Advising acquisition officials on performance issues that may arise regarding an MDAP.

The PARCA office has a relatively limited staff, and reporting deadlines for breaches are short—less than 2 months. Therefore, the director has asked outside organizations, primarily federally funded research and development centers, to assist in conducting the RCAs directed by the

law. RAND has supported the PARCA office by analyzing six programs: the Zumwalt-Class Destroyer (DDG-1000), the Joint Strike Fighter F-35, Longbow Apache Helicopter, Wideband Global Satellite, Excalibur artillery round, and the Navy Enterprise Resource Program. Further, RAND has recently completed the analysis of the Joint Tactical Radio System Ground Mounted radio, the P-8A Poseidon aircraft, and modifications to the Global Hawk Unmanned Aerial Vehicle.[2]

Purpose

This article has four purposes. First, it briefly describes the methodology RAND developed to carry out RCAs. The approach to RCAs has matured over time and may prove useful to other organizations that either must do an RCA or wish to understand what the process involves. Second, it presents an example of such analyses—the Wideband Global Satellite, a program with both significant and critical breaches. Third, the article provides insight into the causes of breaches across several programs. Fourth, it offers lessons learned about breaches and how to avoid them.

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Methodology for Root Cause Analysis

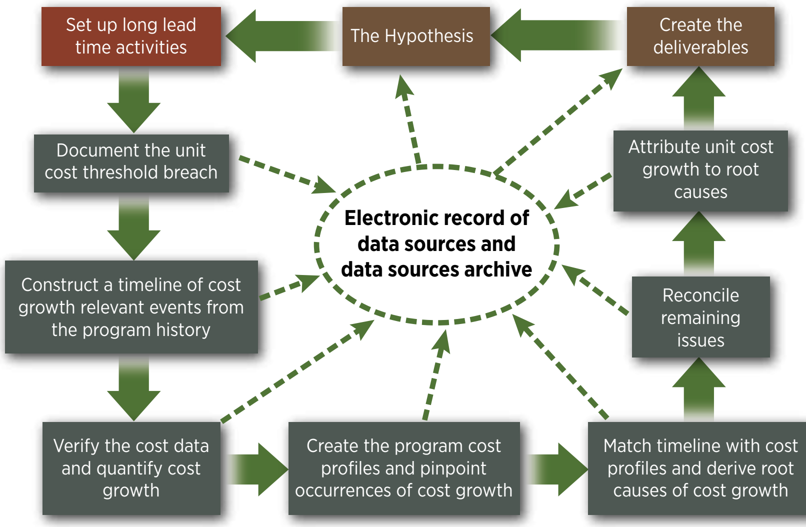
Congressional deadlines for an RCA are tough to meet for two reasons. First, the time available to do them is short. Depending on the circumstances, the RCA must be done in either 45 or 60 days.[3] Second, each RCA is unique because each program is unique. Thus, no "cookbook" spells out all the components and identifies key documents and their locations. RAND has developed a generic methodology, depicted in Figure 2.

The generic process is designed to use the short time available as efficiently as possible. The process is general enough that it can apply to the RCA of any system yet still accommodate the unique attributes of each system. It begins with a hypothesis about what caused the program to breach the threshold. That hypothesis guides many of the subsequent activities, including setting up interviews with key players both in industry and government, which can take some time to arrange. Work has to proceed in parallel so that the required products can be delivered to the PARCA office in a timely manner. In the RCAs performed to date, the PARCA office has requested the following deliverables:

- a completed root cause matrix in the format supplied by the PARCA office;
- a summary narrative;
- a set of briefing charts based on the narrative; and
- a full RCA report.

All deliverables except the full RCA report should be supplied by PARCA office deadlines to ensure that these materials can be used to support the recertification decision.

FIGURE 2. GENERIC RCA METHODOLOGY



Root Cause Analysis of Wideband Global Satellite (WGS) Program

The WGS program was funded in 2001 to acquire an unprotected wideband satellite communications (SATCOM) capability by using a commercial off-the-shelf satellite bus and Ka-band technology, thereby meeting DoD's demand for military SATCOM. WGS provides both X-band communications compatible with the older Defense Satellite Communications System (DSCS) platforms and Ka-band broadcast capability like the Global Broadcast System (GBS). Throughput for each satellite is estimated at over two gigabits per second (U.S. Air Force [USAF], 2007).

The program consists of two phases or "blocks," as shown in the first row of Table 2. Block I of WGS comprises three satellites, the last of which went into orbit in December 2009. WGS Block II consists of three additional satellites—two contracted for the United States to replace aging DSCS and GBS satellites, and a third wholly purchased by Australia in exchange for a percentage of global WGS bandwidth. Block II satellites are essentially the same as Block I, with a high-bandwidth bypass feature for aerial intelligence, surveillance, and reconnaissance platforms (Block I, 2010, p. 16.) With the delays and eventual cancellation of the Transformational Satellite Communications System, DoD

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TABLE 2. WGS AVERAGE PROCUREMENT UNIT COST (EXCLUSIVE OF LAUNCH COSTS)

	Original APB	Current APB/ Original APB	Estimate/ Current APB	Estimate/ Original APB
Block	I	I & II	I, II, IIf	I, II, IIf
Satellites	1–3	1–5	1–8[a]	1–8[a]
Contract type	FFP	FPIF	FPIF	FPIF
APUC	$268m	$294m	$374m	$374m
Unit cost[b]	$239m	$377m[c]	$574m	$574m
% Δ APUC	-	110%	127%	140%
% Δ Unit Cost	-	158%	152%	240%

Note. APB = Acquisition Program Baseline; FFP = Firm Fixed Price; FPIF = Fixed Price Incentive Firm (Target Price).

[a] WGS 6 was purchased for Australia and does not show up in U.S budget accounts.

[b] That is, cost to the government.

[c] Cost claims currently made by Boeing would suggest that the true cost of the first three satellites was roughly $377m.

decided to procure the seventh and eighth WGS satellites—Block IIf—with a planned total buy of 12 WGS satellites to meet future broadband communication requirements (Edwards, 2010).

The Nunn-McCurdy Breach

The unit cost to the government of WGS Block II was roughly 50 percent more expensive than Block I ($377 million compared with $239 million), and Block IIf is again roughly 50 percent more expensive than Block II ($574 million compared with $377 million), as shown in the bottom row (Table 2).

Table 2 illustrates the breach. The 27 percent increase between the current estimate and the current Acquisition Program Baseline (APB) (third column) exceeds the 25 percent threshold for a “critical” breach. (The 40 percent increase [fourth column] between the current estimate and the original APB represents a “significant” but not “critical” Nunn-McCurdy breach.)

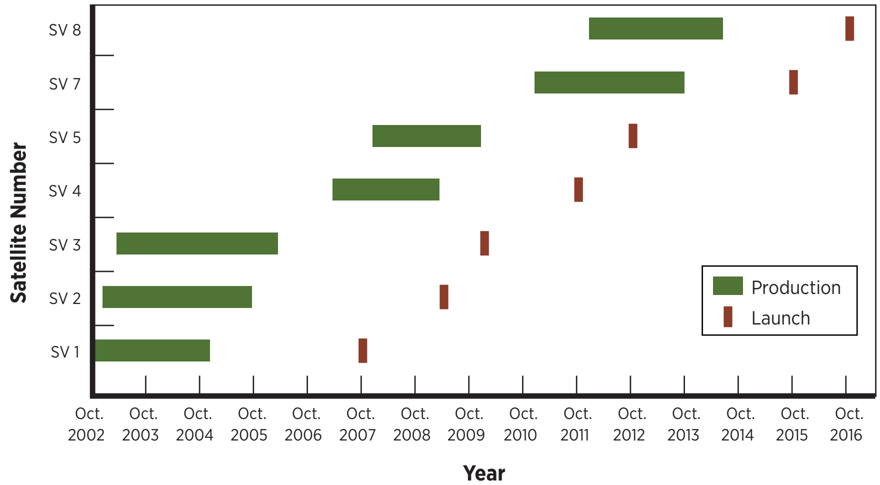
The averages, in turn, permit calculation of a unit cost for Blocks I, II, and Block IIf, but not in a straightforward manner.[4] In real (Base Year [BY] 2001 $) terms, the PAUC of the WGS satellite rose 58 percent between Block I and II (from $239 million to $377 million). Unit costs between Block II and Block IIf are projected to rise 52 percent (from $377

TABLE 3. WGS ORDER AND LAUNCH YEARS

	Satellite	Budget Year	Launch Year	Difference in Years
Block I	1	2002	2007	5
	2	2002	2009	7
	3	2003	2009	6
Block II	4	2007	2011*	5*
	5	2008	2012*	4*
	6 (Aus.)	2009	2013	4*
Block IIf	7	2011	2016	5
	8	2012	2017	5

Note. Aus. = Australia
* These are the launch dates taken from the President's 2012 budget.

FIGURE 3. WGS PRODUCTION/LAUNCH PERIODS



Note. Launches do not include MexSAT-1 and MexSAT-2. Launch dates will follow MexSAT-3.

million to $574 million). Table 3 indicates when each WGS satellite was ordered, when delivered, and the difference in years; Figure 3 indicates the interval during which the USAF-purchased WGS satellites were built and launched. Table 3 indicates a large gap between WGS Block I and WGS Block II, and a smaller gap between WGS Block II and WGS Block IIf. However, the time between program approval and launch for WGS Block I was 5 to 7 years, and the expected cycle time for WGS Block II is

shorter—4 to 5 years. If current launch dates for Block IIf prove accurate, then the gap between Block I and Block II will be somewhat smaller than the gap between Block II and Block IIf.

Sources of the Nunn-McCurdy Breach

The WGS cost breach has two components: the increase in unit costs between Block I and Block II satellites, and the increase in unit costs between Block II and Block IIf satellites. The first difference was ascribed to "what proved to be an artificially low cost for the original three vehicles under a firm fixed-price contract" (Secretary of the Air Force M. B. Donley, personal communication, March 8, 2010). We focus on the latter cost increase, largely because it is the current one and, thus far, more relevant to decisions to be made on the WGS program.

Table 4 shows both blocks in terms of target and ceiling costs. The latter includes margin sufficient to account for the possibility of cost overruns on the FPIF work (combining advanced procurement, base procurement, and launch support costs).

How do $555 million and $410 million in current dollars (Table 4) compare with the $574 million and $377 million (in BY 2001 $)? Table 5 illustrates the difference.

TABLE 4. PROGRAM OFFICE UNIT COST BREAKDOWN (CURRENT $)

	BY	Target	Ceiling
Block II	2007	$355m	$410m
Block IIf	2011	X	$555m

Note. $ shown are program estimates.

Several features merit note. First, storage and factory restart costs were very small in going from Block I to Block II, but substantial in going from Block II to Block IIf even though the gap before restarting production was 4 years for Block II and only 2½ years for Block IIf. We could not explain this difference. Second, in both cases, Other Government Costs (estimated based on data from the program office and Secretary of the Air Force) are fairly large, but roughly the same in both cases. These costs include contracting office and engineering costs; it was *estimated* by subtracting known cost components from total cost components and checked for overall reasonableness and consistency.

TABLE 5. RELATING BASE YEAR AND CURRENT YEAR COSTS ($ IN MILLIONS)

	Block II	Block IIf
Unit cost (BY01 $)	377	574
Inflation factor to current costs	1.14 (BY07)	1.207 (BY11)
Unit cost current year dollars	430	693
Less storage and factory restart	4	73
Subtotal	426	620
Less other government costs	71	65
Subtotal (from Table 4)	355	555

Third, and most importantly, Boeing's price figure for the Block II satellite, as a basis for comparison, is $355 million each rather than the $410 million ceiling price. Why? The $355 million represented the contracted, hence targeted, price of the satellites; if Boeing costs were higher than $355 million, then, under the terms of the contract, the federal government would reimburse Boeing only for 80 percent of those additional costs. The $410 million was the ceiling price; Boeing would have to absorb all costs in excess of that amount. Building the Current APB APUC (for Blocks I and II) out of Boeing's price, but building the Expected APB APUC (for Blocks I, II, and IIf) out of the ceiling price essentially compares apples and oranges. In effect, the WGS program office built a 15 percent factor—essentially an accounting artifact—into the price. We cannot explain the programmers' motivation for doing so, particularly because it led to a critical Nunn-McCurdy breach that otherwise could have been avoided. Whether this difference represents their lack of confidence in the estimate can only be a matter of speculation. Were this 15 percent removed, then the unit cost of Block IIf would have been $516 million (in current $) rather than $574 million, yielding an APUC of $357 million or an increase of 22 rather than 27 percent, representing a "significant" rather than "critical" breach. Nonetheless, $555 million is still a substantial increase over $355 million—and needs to be explained. Table 6 lists the various factors.

We start with Boeing's price of $355 million. Next we add the current cost overrun of 3 percent ($11 million). (Although the final cost overrun may be higher or lower, we presume that cost overruns experienced to date establish a new baseline for what it really costs to build a WGS, hence $366 million.) The next adjustment, line 4, factors in 4 years'

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TABLE 6. COST INCREASE BETWEEN BLOCK II AND IIF (CURRENT YEAR $)

Increase Component	Block II
1. Boeing price (BY 2007 $)	$355m
2. 3% cost overrun	$11m
3. Actual unit costs (BY 2007 $)	$366m
4. Four years' inflation at 3.5% per year	1.147*
5. Expected unit cost circa 2011	$420m
6. Extra tests	$2m
7. Higher component prices for 3 items	$35m
8. Higher component prices overall	$25m
9. Subtotal	$482m
10. Risk premium of 15%	$555m

* (1.035 x 1.035 x 1.305 x 1.035 = 1.147 x $366m = $420m)

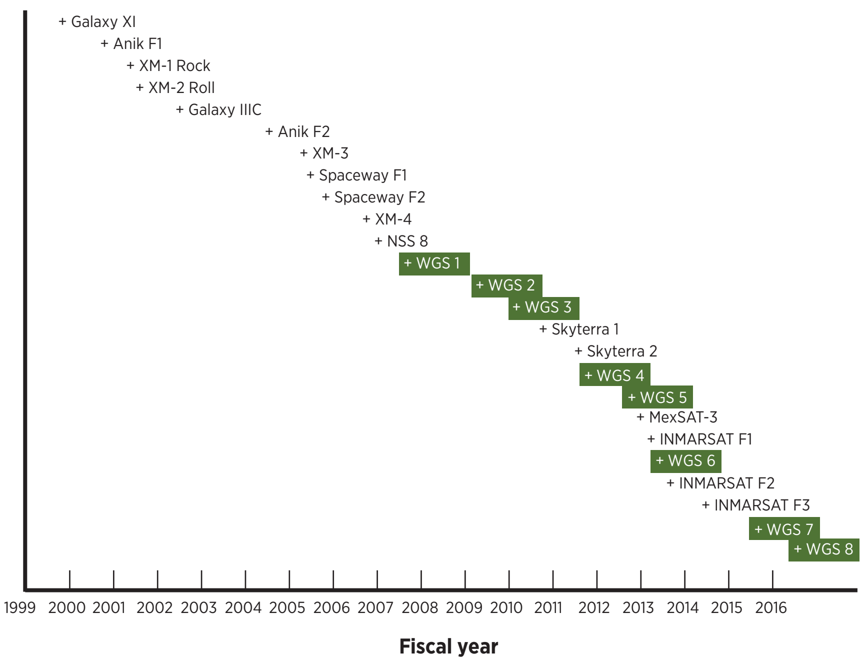
worth of inflation at 3.5 percent per year (as calculated by the program office based on historic experience in satellite component and manufacturing costs),[5] hence the $420 million in line 5. Next comes $2 million for additional tests not required for Block II, $35 million (as calculated by Boeing) to pay for three critical components that might otherwise go out of production,[6] and $25 million (also as calculated by Boeing) for cost increases in other components at risk in the supply chain, hence the subtotal of $482 million in line 9. The last adjustment arises from the accounting artifact noted previously—the difference between contract costs used to calculate Block II prices and the ceiling cost used to calculate Block IIf prices. This brings us to the $555 million that the program office uses to calculate unit costs for Block IIf.

Explaining the Cost Differences

The $60 million in component cost inflation (over and above the normal 3.5 percent a year) shown in rows 7 and 8 of Table 6 requires further explanation. Reflecting a general shift in market requirements, Boeing shifted its commercial satellite offerings from its HS702HP (high-power) bus to its HS702MP (medium-power) bus. This shift has left WGS supporting the production of parts that no longer have much commercial demand, thereby raising the cost of these components. That noted, Boeing also reports that the cost ratio between bus and payload is expected to remain constant, and the cost ratio between component costs and Boeing's costs is also expected to remain constant. Both imply

that its internal costs have also risen more or less proportionately with component costs. This may be reflected in the charges associated with the cold factory restart noted earlier. Figure 4 indicates a sharp decline in commercial satellite production at about the same time that WGS production started. In the 8 years before 2008, Boeing launched 11 commercial satellites; from 2008 to 2016, it plans to launch six. Although the pace of satellite construction has recovered, it has not returned to earlier levels that characterized the first few years of this century.

FIGURE 4. LAUNCH DATES FOR BOEING-PRODUCED SATELLITES



Component cost inflation also reflects a broader phenomenon—the growing divergence between WGS and its civilian counterpart. Commercial products change constantly; military products change infrequently (but in relatively large chunks) and, in the case of Military Specification products, may not change at all precisely because product qualification is complex. In effect, the WGS, born as a modification to a commercial business line, has evolved to a program that is primarily military. As noted, the WGS satellite bus has diverged from its civilian counterpart. The payload of the WGS satellite consists of Ka-band transponders, and X-band transponders and channelizers to switch between the two. X-band is primarily military to begin with. The commercial

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market had flirted with Ka-band 10 years ago, but the trend toward terrestrial (fiber optics and cell phones) rather than satellite-based communications has dampened industry's interest in exploring different spectra whose primary virtue is that they are largely unclaimed. Furthermore, the global business of U.S. satellite manufacturers has been hampered by increasingly stringent application of International Traffic in Arms Regulations starting 10 years ago. Components that once could be supported from both WGS and commercial sales increasingly rely on the WGS market, and suppliers must be paid a premium to remain in the market. Similarly, former WGS workers who could count on transferring their skills into very similar commercial work when gaps appear in WGS, face a harder transition. As one observer (Mecham, 2009) notes:

> In its 10-year history, the Boeing division's main platform, the 702, has commonly served big commercial requirements, such as the three current orders for DirecTV and two for Sky Terra. But the platform also has been used for many of the company's major government programs, most prominently the Wideband Global Satcom (WGS) network of six spacecraft that replaces the Defense Satellite Communications System.... WGS and two other major government programs—the Global Positioning System IIF and GOES N-P series—have provided 90 percent of Boeing's recent work. To redress that imbalance, the company began looking for new commercial market entries four years ago and concluded it could take advantage of the 702's flight software, avionics and power management systems to develop a smaller bus. (p. 66)

The days when commercial sales could buoy the resources put into the WGS program between one buy and the next are gone. The economics of WGS increasingly depend on the pace and scheduling of WGS buys alone.

Root Cause Analysis

The 52 percent increase between Block II and Block IIf unit pricing is primarily due to the first three factors listed in Table 7. Such results are necessarily limited by the 60-day window allowed for investigation under the Nunn-McCurdy legislation that curtailed RAND's ability to question subcontractors and analyze many of the cost claims that had to be accepted as valid over the course of the analysis.

TABLE 7. PRIMARY FACTORS FOR BLOCK II TO BLOCK IIF UNIT COST INCREASE (BY 2001 $)

Factor	$ Amount	Percent
Risk premium accounting artifact	$60m	30%
Storage and restart costs	$57m	29%
Increased component costs	$51m	26%
Other (e.g., SATCOM industry inflation, cost overruns)	$29m	15%

The largest factor—almost one-third of the increase—is an accounting artifact where the Block IIf prices, as calculated by the program office, include a 15 percent risk premium, whereas Block II unit costs do not (because they largely reflect expended rather than projected costs). These results represent an apples-and-oranges comparison. Inasmuch as the Block IIf is practically identical to the Block II units that Boeing is already building, Boeing can be realistically expected to produce the satellites at near the target cost, which is 15 percent below the ceiling cost—although Block II is running 3 percent over target. But the ceiling price is what was reported. Next, Boeing is charging for storage and restart costs for the 2½-year hiatus between Blocks II and IIf. On the surface, the cause appears to be the interruption in production, but the 4-year hiatus (measured, as noted, in terms of when satellites were ordered, not when they launched) between Block I and Block II had a cost of only $3.5 million, or less than 7 percent of the current estimate. One explanation is that significant aspects of WGS production are no longer supported by the commercial market and, therefore, require storage and restart expenses during production breaks. Finally, key components of WGS that are no longer supplied to the commercial market will have greatly increased procurement costs, accounting for another 26 percent of the cost increase. The second and third factors support the argument that the root causes of the breach are changes in the commercial market without corresponding changes in the WGS design and procurement, and obsolescence.

Despite these large cost increases, the WGS program is essentially healthy and relatively well managed. The satellites work; three of them are already on-orbit serving customers. These customers are generally happy, which is part of the reason that the currently planned WGS constellation is larger than the one originally planned (more often, total

buys decline over the life of a contract). There is no reason to expect that the cost of subsequent satellites after WGS 8 will increase—quite the contrary. Boeing's bid proposals for WGS 9 through 12 suggest that these variants will run $100 million less than WGS 7 did (once due account is taken of the baseline inflation in the satellite industry). Thus, although the cost increases in what should be a stable program may appear startling (and remain somewhat startling even after explanation), this is no indicator of a program facing technological or production problems that cannot be reasonably solved.

The broader lesson learned for this program is that when DoD procurement piggybacks on a commercial base—notably the commercial base of a particular company—it takes a risk. The base may shrink, leaving it with less capacity to cover total overhead costs. Even if the base does not shrink, it will evolve. If DoD requirements do not evolve in parallel—and there is no inherent reason why they should—the divergence between DoD's requirements and the market's requirements means that either the requirements are compromised (admittedly, this may be acceptable in some circumstances) or, eventually, such programs have to stand or fall on their own merit. They can no longer be free riders, so to speak. This suggests that a certain procurement discipline is called for, or DoD will pay the difference. Start-stop programs cost more than steady-state programs (i.e., when buys are consistent from one year to the next), which, in turn, are somewhat more costly than total-buy programs. Although DoD cannot necessarily commit to even procurements for a variety of reasons (e.g., changing requirements, risk management, congressional politics), everyone concerned should understand that maximizing acquisition flexibility entails costs.

WGS Conclusions

Three primary factors contribute to the Nunn-McCurdy breach: an accounting artifact, increase in the cost of component parts, and storage and restart costs. Each contributes to about one-third of the cost increase between Block II and IIf. An underlying factor of the increase, particularly with respect to the storage and restart costs, is the change that occurs in the commercial product base that affected the WGS costs. The government incurred additional costs because the commercial base of Boeing no longer supported the WGS.

Common Root Causes and Lessons Learned

Table 8 displays the root causes of breaches in the six programs examined. It places the causes of the various program breaches in three categories: planning, changes in the economy, and program management. The check marks indicate either a root cause or a root cause with relatively greater effect in causing the program to breach.

As can be noted, while these six programs reveal certain cost growth characteristics, they also reflect important differences in how and why cost growth occurred. This point is an important one for policymakers to keep in mind because they sometimes attempt to universalize policies as if all program cost increases stem from common causes.

Understanding the principle that quantity change is rarely a governing root cause for cost growth is fundamental to investigating cases where quantity changes accompany unit cost threshold breaches.

Table 8 indicates that quantity increases or decreases figured into all six of the programs listed. However, RAND's experience suggests that while quantity change can affect a program in important ways, such change is *rarely* the root cause of a Nunn-McCurdy breach. For example, the DDG-1000 program went from 10 ships to 3, which naturally raised the unit cost and signaled a breach. But the reason for the quantity change stemmed from a recognition of changes in the operational environment. Similarly, the increase in the Apache quantities was driven by a decision to procure additional helicopters for operational reasons. Understanding the principle that quantity change is rarely a governing root cause for cost growth is fundamental to investigating cases where quantity changes accompany unit cost threshold breaches. The RAND experience to date shows that although programs had associated quantity changes when they incurred Nunn-McCurdy breaches that triggered RCA examinations, in each case the quantity change was grounded in other program-specific factors that resulted in unit cost growth. Uncovering the grounds upon which quantity changes are founded is an important part of the thorough and insightful RCAs demanded by the WSARA.

TABLE 8. COMPARISON MATRIX OF ROOT CAUSES OF PROGRAM COST GROWTH

Category	Root Cause of Nunn-McCurdy Breach	WGS	Apache	DDG-1000	JSF	Excalibur	Navy ERP
	✓—Root cause ✓✓—Significant root cause						
Planning	Underestimate of baseline cost	✓	✓	✓	✓		✓
	Ambitious scheduling estimates			✓	✓		✓
	Poorly constructed contractual incentives	✓✓			✓		✓
	Immature technologies		✓✓	✓	✓✓		
	Ill-conceived manufacturing process			✓			
	Unrealistic performance expectations			✓		✓	✓
	Delay in awarding contract			✓			✓
	Insufficient Research, Development, Test and Evaluation	✓	✓	✓	✓		
Changes in economy	Increase in component costs	✓✓	✓	✓	✓	✓	
	Increase in labor costs		✓		✓	✓	
	Discontinued/ decreased production of components	✓					

Category	Root Cause of Nunn-McCurdy Breach	WGS	Apache	DDG-1000	JSF	Excalibur	Navy ERP
	Decreased demand for similar technology in private sector (economies of scale)	✓					
	Inflation	✓	✓	✓	✓		
	Production delays	✓✓		✓	✓✓		
	Change in procurement quantities						
	Increase	✓	✓✓				✓
	Decrease			✓✓	✓	✓	
Program management	Unanticipated design, manufacturing, and technology integration issues		✓✓	✓	✓✓		✓
	Lack of government oversight or poor performance by contractor personnel			✓	✓		
	Inadequate or unstable program funding	✓	✓	✓	✓	✓	✓
	Accounting artifact	✓					

Note. DDG = Guided Missile Destroyer; ERP = Enterprise Resource Planning; JSF = Joint Strike Fighter.

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Based upon our research into the root causes of breaches of the programs analyzed thus far, and an examination of similarities and differences as reflected in Table 8, RAND offers three overarching recommendations:

1. In the development of early program planning, understand thoroughly the implication of the testing regimes and the numbers of test articles required to execute those regimes. Planning for the testing regime and use of simulation cannot be overstated. As noted in previous RAND research, the F-35 exemplified that problem (Blickstein et al., 2011, pp. 1, 15–16).

2. Clearly stipulate costing methodologies that rely on commercial production or even commercial production practices. The danger is both that necessary cost controls will not be implemented and that important cost analysis alternatives will not be recognized and used. Based on research conducted by RAND with the PARCA at the WGS program office, there does not appear to be a good understanding that fabricating a vehicle to be used by the military can cost significantly more than a commercial vehicle with an international "list price."

3. Where a program depends upon planned product improvements over time, ensure a clear understanding of relationships among several factors, primarily time in inventory, ongoing research and development, and periodic platform upgrades or blocks through the entire out-year period. Failure to understand this can cause program managers to lose sight of program cost growth, as was the case with the Apache Longbow.

Acknowledgment

We are indebted to our RAND colleague, Martin Libicki, for his analysis and description of the root causes of the Nunn-McCurdy breach on the Wideband Global Satellite.

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Endnotes

1. The SAR's initial purpose was to act as a vehicle to keep its sponsor, the Assistant Secretary of Defense (Comptroller), apprised of the progress of selected acquisitions and to compare this progress with planned technical, schedule, and cost performance. In February 1969, the Chairman of the Senate Armed Services Committee asked the Secretary of Defense to provide status reports on major weapons systems. The parties agreed in April 1969 that the SAR would be the vehicle to satisfy the committee's needs (U.S. General Accounting Office, 1980).
2. RAND is a nonprofit institution whose mission is to help improve policy and decision making through research and analysis. The name is an acronym for "research and development."
3. The 45-day period between program manager report of a breach and military department secretary notification of a critical unit cost breach to Congress starts the day after the initial report of the breach to the Service Acquisition Executive. The 60-day period within which the Secretary of Defense must submit a program recertification decision to Congress starts on the day after the due date of the first SAR that reports the breach.
4. Note that the original APB was $268 million (fifth row, Table 2) per satellite, but the unit cost is now estimated to be $239 million (fourth row, Table 2). The difference between the two is accounted for by the fact that other government costs ended up $29 million per satellite lower than estimated.
5. Note that this 3.5 percent exceeds the 1.8 percent used as an overall price deflator by the Office of the Secretary of Defense to convert constant into current dollars.
6. The three critical components that might otherwise go out of production were the Xenon Ion Propulsion System (XIPS), certain transponders, and a crypto box.

Keywords: *Reuse, Legacy, Reuse Framework, Evaluating DoD Legacy Systems*

Reusing DoD Legacy Systems: *Making the Right Choice*

Meredith Eiband, Timothy J. Eveleigh, Thomas H. Holzer, and Shahryar Sarkani

Department of Defense (DoD) programs often experience cost overruns and technical difficulties due to reuse of legacy systems. With today's fiscal climate of resource-constrained DoD budgets, reuse of legacy systems is frequently touted as the solution to cost, efficiency, and time-to-delivery problems; however, cost overruns and technical difficulties can significantly diminish any perceived benefits. Through evaluation of eight diverse DoD programs, this research shows that the state of a legacy system's documentation, availability of subject matter expertise, and complexity/feasibility of integration are key factors that must be analyzed. Based on these three key factors, the authors propose a framework to aid both the DoD and defense contractors in the evaluation of legacy systems for potential efficient and effective reuse.

Image designed by Diane Fleischer »

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Within the DoD, there is an increasing need to deliver products that are both technologically cutting-edge and affordable. Currently, the DoD budget is facing sequestration and planned reductions, cost overruns of DoD acquisition programs over a 7-year period were approximately $919 billion (Defense Business Board, 2010). At the same time, a survey of all DoD programs shows that the DoD acquisition life cycle, which begins at the identification of needs, goals, and objectives and completes at the disposal of the system was on average 11 years (Tomczykowski, 2001). One potential solution to the issues of cost overruns and prolonged acquisition timeframes is to reuse DoD legacy systems. While this may seem like an ideal solution due to the legacy system being complete, tested and even operational, reusing legacy systems can lead to unforeseen technical complications and financially prohibitive difficulties when integrating with newer technologies. A prime example of this is the potential to have a technological gap between the legacy system and the newly created system. In this instance, additional cost is frequently incurred when developing the solution for the systems to work in unison.

Interestingly, even the terms "reuse" and "legacy" have multiple definitions depending on their source. In the software engineering domain, the term *reuse* may imply that a software product was designed as a reusable building block. For this study, it was imperative to derive a definition from established sources that did not limit the study or exclude other forms of reuse that are common within the DoD. Similarly, definitions of legacy systems abound, and often the term is used to simply describe a system that is considered old. However, within the DoD, the term *legacy system* has a much more specific meaning. In the DoD context, a legacy system's age does not distinguish it as legacy, but merely denotes that the system is one in which DoD has a substantial investment of both time and money (Defense Acquisition University [DAU], 2009). To investigate this topic, the authors used the following taxonomy of terms:

- *Reuse* – the integration of an already developed part (e.g., engine), product (e.g., inventory database), or legacy system (e.g., telemetry processing system) into another context or component.

- *Legacy System* – "a system or application in which an organization has already invested considerable time and money" (DAU, 2009).

Despite the challenges involved in the reuse of legacy systems, defense contractors, whether required by contract or by design, are regularly agreeing to do so as a cost and schedule mitigation strategy without either the U.S. Government or the defense contractor fully analyzing what the effect of reuse may actually be on the cost, schedule, risk, and performance of the product life cycle (General Accounting Office [GAO], 1993). In some cases, reuse of a legacy system provides an affordable and efficient alternative to a newly developed system, as in the KC-135 Stratotanker. In this case, the original fleet has been updated, retrofitted, and modified over 12 times in the last 50 years, each time saving the DoD the estimated $40 billion cost of developing a new aircraft for a similar purpose (GAO, 2004; Clark, 2010). On the other hand, the Navy Marine Corps Intranet (NMCI) contract was grossly underestimated by both the prime contractor and the U.S. Government, and as of 2007, the prime contractor had lost $3 billion (Jordan, 2007). One of the many continuing struggles on the NMCI program is the incorporation of tens of thousands of different legacy software versions and applications into a common operating environment (Jordan, 2007). Given the valuable lessons observed (and maybe learned) from these and many other programs, what factors are critical to consider before deciding to reuse a legacy system?

Reusing legacy systems can lead to unforeseen technical complications and financially prohibitive difficulties when integrating with newer technologies.

Research into the application of software reuse is plentiful, and generally falls into three common themes: theoretical work, cost impacts, and software tools used to aid in the reuse process. In the area of theoretical work, researchers have developed software legacy and reuse-based acquisition life-cycle frameworks (Ahrens & Prywes, 1995), described the causes of technological uncertainty (Fleming, 2001), discussed implementing design reuse (Gil & Beckman, 2007), formalized reuse processes (Redwine & Riddle, 1989), defined strategies for reuse (Frakes & Terry, 1996), and created a better reuse design based on knowledge management techniques (Hicks, Culley, Allen, & Mullineux, 2002). The literature surrounding the cost and economic impacts of reuse include works tying cost to software development (Wang, Valerdi, & Fortune, 2010), updating software cost models for current issues (Boehm et al.,

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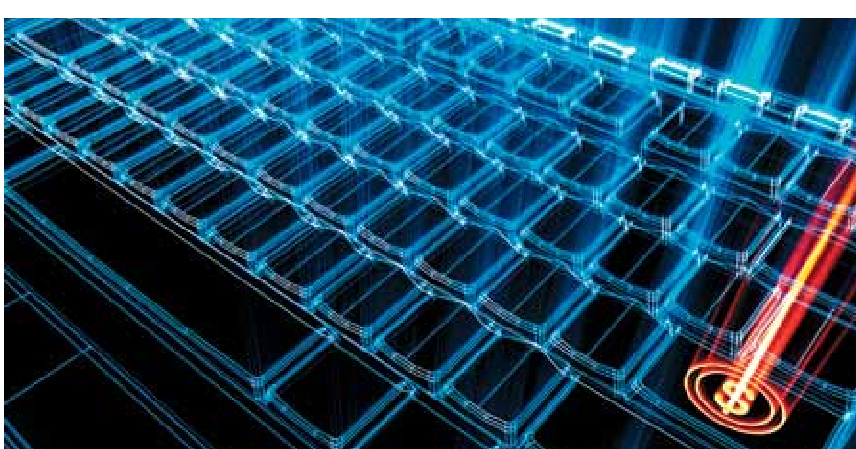
2000), and evaluating the impacts of the cost of software reuse (Boehm, 1981; Gaffney & Durek, 1989). Perhaps the most expansive studies in reuse are derived from the creation of software tools and applications. Examinations in this area include work in evaluating reuse through a total system approach (Kim & Stohr, 1998; Mili, Mili, & Mili, 1995; Isoda, 1995) and exploring reuse abstraction (Freeman, 1983).

Regardless of all of the theoretical work, tools, and cost models available, one key area remains inadequately researched: how program managers should determine whether or not they will efficiently and effectively reuse hardware and software legacy systems based on cost, schedule, risk, operations and maintenance (O&M), and performance. To investigate this, an interpretive case study approach was used to evaluate a group of DoD programs to accomplish three objectives:

- Identify the key factors decision makers need to consider when determining whether or not to reuse legacy systems.
- Determine how often the key factors have an impact on studied programs and what preventative measures could be applied to diminish unsuccessful reuse of legacy systems.
- Create a framework of imperative questions and quantifiable answers that can improve the decision maker's ability to pinpoint which legacy system opportunities for reuse stand the greatest chance of success.



Identifying Key Factors in Reusing Legacy Systems

Eight existing DoD programs spanning the areas of aircraft, information technology, systems of systems, communications, satellites, and facilities were used as a sample of DoD program domains where reuse of legacy systems exists. Programs were delineated by their capacity to successfully reuse DoD legacy systems. For this study, successful reuse was based on each program's capacity to reuse a legacy system within the projected cost, schedule, risk, and performance baselines. Data—including GAO reports; program-specific lessons observed; and independent third-party analyses that explored cost, schedule, risk, performance, and O&M impacts—were used to determine the success or failure of legacy system reuse. Additionally, data were analyzed to ascertain the fundamental reasons that cost, schedule, or risk increased on the program.

To substantiate the findings of this study, the collected data were then validated by experts in the field of systems engineering who were familiar with the programs selected. Data were also controlled for factors that were outside the control of either the DoD or the defense contractors. For example, six of the programs studied have acquisition life cycles of 10 years or more, and thus were more susceptible to volatility in their budgets. Since budget fluctuations are often out of the control of both the DoD as a whole and defense contractors in particular, any results that were directly influenced by these types of external causes were not included in the final analysis.

Upon initial review of the eight programs, three recurring factors were found when programs were unsuccessful in reusing legacy systems:

- Substandard, inadequate, or nonexistent systems engineering documentation including: requirements, architectures, statements of work, work breakdown structures, concept of operations, test documentation, and standard operating procedures.

- Insufficient subject matter expertise including: inadequate identification of current users of the legacy system, little or no accounting for training existing employees on the system,

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and assuming experts within a specific field should be able to operate the system simply because of the interrelationship between the newer system and the older legacy system.

- Inadequate analysis of the cost, schedule, and risk of integrating a legacy system including: incompatible technologies, inadequate security postures of the legacy systems against the current security landscape, substandard processing of data after integration, and creation of additional systems or functions to connect the new pieces of the system to the legacy system.

Conversely, for the programs that successfully reused legacy systems, these factors were either addressed early in the program life cycle or accounted for in the reengineering work associated with the program. To fully validate the dominance of these key factors, the eight programs and their software and hardware projects were evaluated against the following three hypotheses:

- *Hypothesis 1:* Decision makers overestimate the quantity and quality of legacy system documentation available.

- *Hypothesis 2:* Decision makers underestimate the criticality of legacy system subject matter expertise.

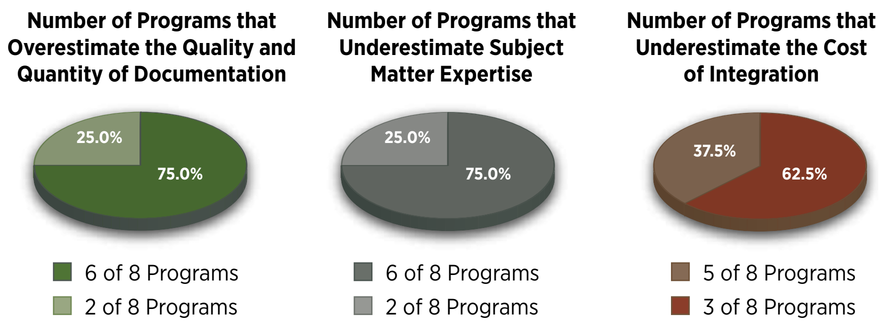
- *Hypothesis 3:* Decision makers underestimate the time, cost, and feasibility of the integration phase.

Frequency of Factors

Of the eight programs analyzed, six of the programs overestimated the quantity and quality of legacy system documentation (Figure 1). When unsuccessful programs did have documentation, the quality of the documentation did not meet the industry or military standard, and thus required additional effort to meet these standards. Similarly, a different set of six of the programs also overestimated the cost and time to delivery of integrating new technology with the applicable legacy systems, while another set of five program decision makers underestimated the criticality of legacy system subject matter expertise. Unsuccessful program teams that did not understand the importance of subject matter expertise often employed personnel who were experts in a specific field

related to the legacy system, but who had never worked on that system specifically. In this situation, all five of the program managers quickly exhausted the budget and schedule resources allocated for training their staffs, and even then fell short in the area of system knowledge.

FIGURE 1. FREQUENCY OF KEY FACTORS



Quality and Quantity of Documentation

Data analysis shows that decision makers overestimate the quantity and quality of on-hand legacy hardware and software system documentation 72.7 percent of the time. In fact, three of the programs studied had little to no requirements, architecture, statement of work, or work breakdown structure artifacts for the legacy systems involved. Due to ever-evolving military and industry standards for documentation within the systems and software engineering fields, gaps often exist in quality and quantity of requirements, operational concepts, and legacy architecture documentation, which must be understood prior to beginning the program life cycle. These artifacts frequently must be redocumented to current standards during the initial phase of the program to satisfy contractual deliverables. If the level of redocumentation is not bid into the contract, the unscoped efforts directly impact program planning, resources, and performance. This leads to higher risk, additional costs for either the DoD or defense contractor depending on the contract vehicle type, and the possibility of schedule impacts, thus having a negative impact on successful legacy system reuse.

This conclusion held true for 100 percent of programs that reused legacy software systems, but it only held true for 50 percent of programs that reused hardware components (Figure 2). Since the relative age of the software engineering field is less than that of the hardware engineering field, these results are not entirely surprising. The software engineering

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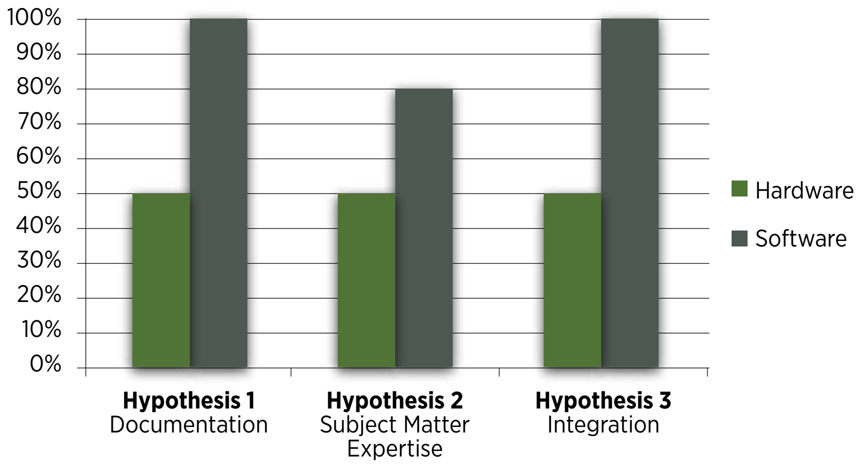
field is still maturing in the frameworks used to apply it, which includes how systems are documented and to what degree. The initial results indicate that while reviewing and obtaining documentation is a challenge for the vast majority of programs regardless of the hardware or software system being built, added diligence is warranted when reusing DoD legacy systems. Based on these findings, the hypothesis that decision makers overestimate the quality and quantity of legacy documentation is supportable.

FIGURE 2. COMPARISON OF HARDWARE AND SOFTWARE PROJECTS



Subject Matter Expertise

The analysis illustrates that decision makers do in fact underestimate the importance of having the correct subject matter expert at the right time for the program 62.5 percent of the time on both software and hardware projects. When proper subject matter experts are not engaged, knowledge recovery becomes a critical endeavor in understanding the legacy system. In particular, knowledge recovery activities included legacy system training, additional documentation of system operating procedures, and specialized use cases. During the planning phase, four of the programs studied had unquantified knowledge recovery efforts. Data show this added time to schedules and raised the cost of the program while inexperienced employees were brought up to speed. Programs on which underestimation of subject matter expertise occurred shared the common problem of hiring experts in a field of study that includes the legacy system, while assuming that the experts could immediately begin working on that system. The field subject matter experts were often

very knowledgeable, but did not have the specific knowledge that comes from working directly on or with the legacy system, which increased the learning curve and, subsequently, program cost and schedule. Similarly, hiring additional manpower after these realities were established typically occurred too late to effectively mitigate their impacts.

When obtaining experts for hardware and software components, a common problem is the complex and unique nature of the DoD application of a given capability. The DoD regularly pushes the bounds of common hardware and software tools by using commercial equipment that is often designed for smaller and less intricate applications. In these cases, expertise is imperative, as even the experts in the field are challenged by the application of a legacy system. To lessen the effects of inexperienced staff, the DoD and defense contractors should determine the complexity of the legacy system and what, if any, legacy experts should be employed on the program to ensure successful delivery.

Of the programs that reused legacy software systems, 80 percent underestimated the importance of this factor, while this was only true of 50 percent of hardware programs (Figure 2). This result emphasizes the importance of subject matter expertise to both hardware and particularly software programs. Since legacy DoD software can be unique, special attention should be paid to hiring staff with particular expertise for the given legacy system. These results show that underestimation in this area can significantly degrade the success of reuse.

Feasibility of Integration

Data show that decision makers on the programs in the analysis underestimated the time and cost of integrating with legacy systems 72.7 percent of the time. For example, on one program in the study, the original bid included an assumption that the outdated software code could be converted and ported to new hardware to reduce the cost of purchasing or developing completely new software. Despite careful analysis and hiring subcontractors specializing in performing this task, the integration failed. Further, the schedule was impacted, and the subcontractor was still performing work to create a usable system at the time the data were collected. With work still being performed on this system, the benefit of reusing the legacy software cannot be calculated, but it is likely that this rework activity will add to the schedule, cost, and risk of the program. In the previous example and others like it, the program risk profile will be increased, and the probability of impacts to

both cost and schedule is greater without active risk mitigation strategies in place (Bennett, 1995). As identified by Orrego and Mundy (2007), there is little research into the level of risk impact when reusing systems. Because of this, an opportunity exists for future research in this area to further refine the decision-making process for reuse and develop risk mitigation techniques that program managers can leverage to better manage reuse-related technical risks.

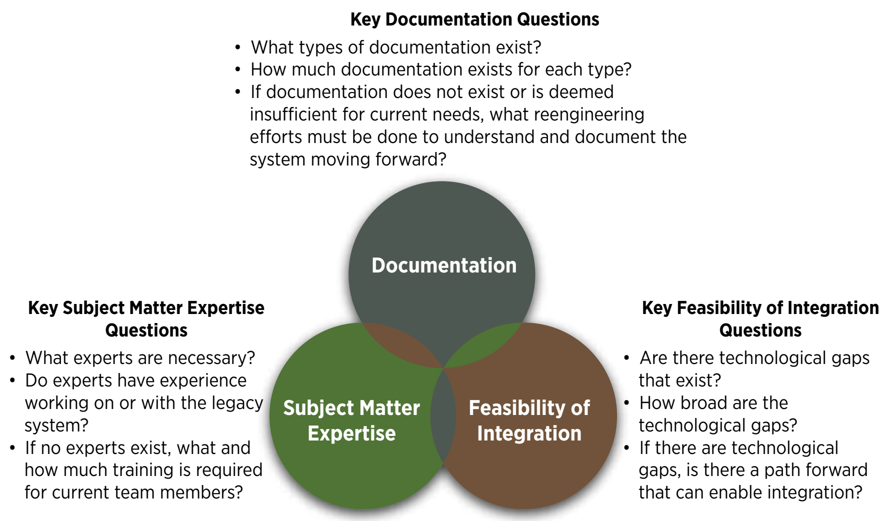
Security implications must also be considered in any analysis of a legacy system's integration potential. The rapid pace of change in today's security environment will likely necessitate significant penetration testing, security scanning, and hardening to identify vulnerabilities and retrofit any legacy system to meet current DoD and industry standards. Additionally, the cost and risk of reusing hardware or software in a classified environment can increase the complexity of integration. Intensive systems engineering and security architecture analysis will likely be required to ensure that classified data security is not put at risk due to latent vulnerabilities that may be exposed when integrating with a legacy system. As observed on one of the programs studied, underestimation of these efforts at the beginning of a project drives significant unplanned investments later in legacy system reuse projects—even if only to navigate the complex government processes required to pursue waivers or deviations for any vulnerabilities that cannot be overcome without prohibitively high additional costs (Jordan, 2007).

Legacy System Reuse Framework

Documentation, subject matter expertise, and feasibility of integration were all found to impact legacy reuse success individually, but they were consistently found to overlap with compounding effects (Figure 3). On programs with little documentation, 87.5 percent of the programs underestimated the criticality of obtaining the correct experts at the proper time, and this directly impacted the time and cost required for integration. An additional finding shows that there may be a relationship between the age of a legacy system and the feasibility of its reuse due to a confluence of the factors discussed here. Data show that programs that reuse increasingly older legacy systems had not only larger documentation gaps, but also difficulty bridging the technological divide between the new and old parts of the system. All five of the software programs had documentation gaps, but of those systems, the two attempting to use software systems older than 10 years had virtually no requirements, architecture, or operational concept documentation to leverage. Given

the clear impact that this has on subject matter expertise retention and integration facilitation, this demonstrates that there may, in fact, be a tipping point at which a legacy system's age directly determines the feasibility, or lack thereof, of reusing that system.

FIGURE 3. KEY FACTORS IN REUSE



In these cases, by the time problems are identified, efforts must be made to provide proof of why the legacy system is not suitable, thereby adding yet more cost to the effort. At the point that a subsequent judgment on suitability is rendered, pursuit of a more optimal solution may no longer be an option. Due to the investment and development already done on a reuse-based system, creation of an optimal, new solution may be outside of the acceptable cost for the final product. Interrelation of these factors necessitates their consideration individually and collectively to properly assess areas of compounding risk.

Within each of the key reuse factors shown in Figure 3, imperative questions should be answered prior to the decision point of determining whether to reuse a legacy system (Table). These questions were developed by isolating the problem areas identified from the research that contributed to cost and schedule impacts on each program. Similarly, programs that were successful were analyzed for mitigation strategies applied. Based on this analysis, a question-based framework was developed, and standard quantification methods were applied to each area. Program decision makers employing this methodology will need

TABLE. REUSE EVALUATION FRAMEWORK

Reuse Factors	Key Questions for Analysis	Quantification Method

Documentation	• What types of documentation exist?
	  ◦ Operational Concept
	    - Use cases
	  ◦ Requirements
	  ◦ Architecture
	    - Functional Flow Diagrams
	    - Activity Diagrams
	    - Block Definition Diagrams
	  ◦ Work Breakdown Structure
	  ◦ Design
	    - Software Design Documents
	    - Hardware Design Documents
	    - Interface Control Documents
	  ◦ Test
	    - System Acceptance Test Plans/Results
	    - System Integration Test Plans/Results
	    - Security Test and Evaluation Plans/Results
	  ◦ Security Analysis
	    - System Security Plan
	  ◦ System Operations and Maintenance Procedures
	  ◦ Industry or Military Standards
	• How much documentation exists for each type?
	• If documentation does not exist or is deemed insufficient for current needs, what reengineering efforts must be done to understand and document the system moving forward?
	  ◦ What are the contract line item deliverables?
	  ◦ Are there documents that are necessary, but not listed in the contract line item deliverables?
		• Cost – based on prior documentation or redocumentation efforts
		• Schedule – based on prior basis of estimates for length of documentation activities
		• Risk – based on risk assessment of documentation availability

Reuse Factors	Key Questions for Analysis	Quantification Method
Subject Matter Expertise	• What experts are necessary to understand the legacy system? ∘ Are there experts within the DoD or within industry? ∘ Will the contractor need assistance in locating experts if they reside within the DoD? • Do they have experience working on or with the legacy system? • If no experts exist, what training and how much training is required for current team members? ∘ Is there a similar system where experts may have overlapping skills?	• Cost – based on training and personnel hours • Schedule – based on training efforts and transition period • Risk – based on risk assessment of subject matter expertise availability
Feasibility of Integration	• Are there technological gaps that exist? ∘ Compatibility of legacy software and/or hardware with the new system ∘ Data transfers and protocol ∘ Performance requirements in the new environment ∘ Platform differences ∘ Security standards and accreditation • How broad are the technological gaps? ∘ Would a technical solution be more difficult to implement than selecting nonlegacy hardware or software? • If there are technological gaps, is there a path forward that can enable integration? ∘ Is there a common technical solution, how often is it used, and with what results?	• Cost – if the legacy technology can be integrated • Schedule – if the legacy technology can be integrated • Risk – based on risk assessment of technological gaps and cost and schedule flexibility

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to collect and apply their own program-specific data to feed the framework. In turn, a determination on a legacy system's candidacy for reuse success may be more easily obtained. The framework can be used to augment these and other traditional analysis methods, thereby allowing decision makers to bring the frequently overlooked or underestimated legacy system factors into the decision-making process.

Based on the answers to the questions outlined in the framework, the decision maker can associate cost, schedule, and risk with any redocumentation effort. These quantification methods should be based on historical data collected and applied for analogous proposal activities. Similarly, cost, schedule, and risk can be associated with subject matter expertise. Feasibility of integration can be linked with risk, cost, and schedule; and if there are technological gaps that can be solved, the program can associate cost and schedule impacts. If a technological gap cannot be reasonably overcome, the program manager should not reuse the legacy system and instead begin work to identify alternative solutions. By utilizing these measurements, program managers can make an informed and grounded estimation of the costs, schedule, risk, performance, and O&M needed to successfully reuse the legacy system.

Conclusions

Reuse of DoD legacy systems is a tempting enterprise for both the DoD and defense contractors, but the perceived value of reusing a legacy system is often outweighed by the very real technical difficulties and costs associated with doing so.

With improved upfront analysis, a smarter application of reuse can play an important role in diminishing time to market and affordability initiatives. However, early analysis is rarely done. Despite the fact that two of the programs within this study were able to successfully reuse legacy systems, the overall findings suggest that the decision to do so is not being assessed properly on these programs, particularly since no reuse analysis was performed prior to the decision to go forward. In fact, all five of the program managers who reused software in this study overestimated the quality and quantity of documentation needed as well as the feasibility of integration; and 80 percent of the program managers who reused software underestimated the criticality of legacy system subject matter expertise. While legacy hardware reuse was more successful, 50 percent of these programs also succumbed to improper

estimation of the key factors outlined here. With so many unaccounted activities, program managers—not surprisingly—will see overruns in cost and schedule on programs where legacy system reuse is attempted.

> ***Reuse of DoD legacy systems is a tempting enterprise for both the DoD and defense contractors, but the perceived value of reusing a legacy system is often outweighed by the very real technical difficulties and costs associated with doing so.***

These findings underscore the necessity of utilizing a framework to quantitatively evaluate legacy systems prior to the decision to reuse them. Both the DoD and defense contractors can benefit from application of this framework. Contractors can use it to justify the inclusion of reuse in a proposed solution, or alternatively to justify higher initial costs to perform ground-up development and avoid reuse altogether. The DoD can additionally leverage this framework to perform an independent analysis of contractor bids and ensure that reuse feasibility was adequately evaluated by each contractor. All too frequently, proposals including reuse in the solution space are enticing because of their lower cost estimates and other perceived benefits, but when these benefits fail to materialize, the damage is already done. Since no two programs are alike, applying this framework in conjunction with developing a comprehensive risk profile and performing a cost–benefit analysis will provide a more complete examination of reuse potential. A combination of these techniques to perform such analyses could also be a valuable subject for future research.

Of importance to note is that even if the cost of reusing a legacy system is more than what was budgeted, reusing the legacy system may still be a more efficient and effective alternative in terms of cost, schedule, performance, and risk than building an entirely new system. In this instance, the framework should be used to aid in better cost estimation during the discovery and contracts phase of the acquisition life cycle. The results of such rigor would benefit both the DoD and defense contractors alike. Unless an analysis is performed, the implications of reusing a legacy system are entirely unknown.

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Keywords: *Contracting, Economic Price Adjustment (EPA) Clauses, Risk, Target Fee*

Valuing the Cost of an Economic Price Adjustment Clause to the Government

Scot Arnold, Bruce Harmon, Susan Rose, and John Whitley

An Economic Price Adjustment (EPA) clause in a contract allows for adjustment of contract price if certain conditions are met. The Department of Defense (DoD) often uses an EPA clause in contracts where there is an increased risk that the costs of inputs used by the contractor will diverge from the forecasts used in the original pricing of the contract. EPA clauses transfer risk from the contractor to the government; thus, they are of economic value to the contractor. This article reviews EPA clauses, analyzes the value of risk transfer, and discusses how DoD could account for this value in negotiating fees for contracts that contain EPA clauses. Other government costs and risks associated with EPA clauses are also discussed.

Image designed by Diane Fleischer »

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An Economic Price Adjustment (EPA) clause in a contract allows for adjustment of contract price if certain conditions are met. The Federal Acquisition Regulation (FAR) (2005) permits use of an EPA clause when "there is serious doubt concerning the stability of market or labor conditions that will exist during an extended period of contract performance."[1] The DoD uses EPA clauses in areas like multiyear procurement (MYP) contracts; for example, recent C-17, F/A-18 E/F, and AH-64D Apache Longbow MYP contracts all contained EPA clauses covering certain labor costs and contracts for highly volatile commodities, e.g., fuel.

EPA clauses transfer risk from the contractor to the government; thus, they are of economic value to the contractor. For example, a contractor may be able to get better financing terms for a project, given the contractor's lower risk exposure. In other areas of government contracting, hedging a contractor's risk is grounds for adjusting the target fee used in establishing contract price. For example, the Defense Federal Acquisition Regulation Supplement (DFARS) recommends using a higher target fee in a Firm Fixed Price (FFP) contract than in a Fixed Price Incentive Firm (FPIF) contract, where more risk is shared with the government. But, the weighted guidelines method contained in the DFARS does not clearly address how to adjust target fee[2] when an EPA clause is used.[3] After a brief review on the background of EPA clauses, this article analyzes the potential value of EPA clauses and discusses how this value could be taken into account in negotiating a contract.

Background

A fixed price contract commits the contractor to absorb the cost risk associated with providing the agreed-upon product or service. Cost risk can result from unexpected changes in input prices, unfavorable changes in a manufacturing process, labor strikes that shut down production, or other unforeseen events. This works both ways for contractors. If they are not able to control costs, they are exposed to losses; if they are able to control and reduce costs, they retain the higher profit.

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Different types of contracts distribute risk between contracting parties in various ways. An FPIF requires the contractor to share cost changes from a negotiated target while an FFP contract puts all of the cost risk on the contractor. EPA clauses place the inflation risk for certain elements of cost—e.g., steel, titanium, labor, or a combination of cost elements—with the government.

The typical EPA clause specifies "[a]djustments based on cost indexes of labor or material" (FAR, 2005). The indexes chosen should be correlated with the cost elements at risk, but should also be broad enough to be outside of the contractor's control (DFARS Procedures, Guidance, and Information, 2012). Most EPAs are written with symmetry between upward and downward price adjustments. However, contractors who have the greatest exposure to upward pressure on input costs will more likely prefer an EPA clause. An EPA clause would be disadvantageous to those expecting a decrease in input prices (which would normally lead to higher profits); to the degree that contractors can influence whether an EPA clause is included, this would result in a higher incidence of upward price adjustments.[4]

In addition to the intended transfer of risk for particular labor or material inputs, EPA clauses can entail unintended risks from such things as poorly chosen indexes and strategic behavior driven by the existence of the EPA clause. The choice of the price index is important. Researchers of past studies have found difficulties in the application of EPA clauses. In some cases, the EPA clause was linked to price changes that were not sufficiently coupled to the actual underlying inputs to the contract that established the need for the clause. We refer to this as "basis risk." For example, Keating, Murphy, Schank, and Birkler (2008) found that the Steel Vessel Index, constructed in the 1950s to track the prices of common materials used in ships, was not representative of

modern naval vessels and had been substantially more volatile than the prices of common input materials for modern naval ships. To overcome this inaccuracy, several ship program managers have created their own materials cost indexes.

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The DFARS directs that the costs subject to the EPA be fixed at contract start, including the proportions of labor and material, and their allocation across time. This is intended to limit the contractor's ability to shift resources and "game" the EPA clause once a contract has started. Choice of index is also important in limiting gaming of an EPA clause, as some indexes that have been used could allow the contractors' actions to affect index values. For example, in the first F/A-18E/F MYP contract, an index based on the contractor's actual labor rates was used.[5] The Department of Defense Inspector General (DoDIG, 2008) found that Boeing's prefunding of pension liabilities directly affected the Bureau of Labor Statistics' aircraft industry labor compensation index, which was used in calculating EPAs for three Boeing contracts. These unintended risks may result in payments to the contractors that otherwise would not have occurred. Updates to the DFARS and improvements in government/industry practice have better regulated these issues; the F-22 MYP contract includes a good example of a well-written EPA clause. In this case, the portions of contract cost affected were narrowly defined, and the labor indexes specified used a broad formulation for fringe benefits. However, given imperfect information and the limitations of available indexes, the possibility of using an inappropriate index remains.

EPA-like clauses are also used to mitigate risks in commercial, long-term supply agreements in capital-intensive industries (Goldberg & Erickson, 1987). A common objective of these agreements in commercial transactions is to stabilize supply availability; the purpose of the EPA-like component is to transfer pricing risk to the party most able to manage it. Like an EPA clause in a government contract, the private contracts use a price index to adjust the transaction price in the long-term agreement. For example, a supplier of wrought titanium might index processed mill product prices to the cost of titanium sponge. Public firms must estimate the value of these EPA-like clauses for their quarterly and annual financial reporting if the language of the clause implies an embedded risk option. In some cases, the firm can use market prices for similar options for a valuation; in other cases, it must use a

model. For estimating the value of an EPA clause in a defense weapons system contract, the same process can be applied. The valuation method is dependent on the type of commodity covered under the clause.

Value of Risk Transfer in Government Contracts

EPAs in government contracting transfer risk from the contractor to the government. In commercial transactions of this sort, the party that "sells" risk is expected to pay a premium to the party that "buys" risk. The financial and insurance industries have developed sophisticated tools for estimating the value of risk, thus the "premiums" that should be paid for various types of risk transfers. In government contracting, the premium would be paid by a downward adjustment to the target fee earned by the contractor, set during determination of the contract price. The DFARS does not clearly address fee adjustments to account for the risk transfer when including an EPA clause.[6] Presently, contracting officers use their own judgment in determining whether to reduce the contract fee to reflect the lower cost-risk exposure, and no guidance is provided to contracting officers as to what might be an appropriate adjustment level.

The DFARS does take into account other forms of risk transfer and provides recommendations on target fee adjustments to account for their value, e.g., moving from an FPIF to an FFP contract. These recommendations can provide rules of thumb for valuing other types of risk transfer. The Table lists the range of fees paid for contract risk based on contract type.

TABLE. DFARS CONTRACT RISK FEE POLICY

Contract Type	Normal Value	Designated Range
Firm-fixed-price (FFP), no financing	5.0%	4 to 6%
FFP, with performance-based payments	4.0%	2.5 to 5.5%
FFP, with progress payments	3.0%	2 to 4%
Fixed-price incentive (FPI), no financing	3.0%	2 to 4%
FPI, with performance-based payments	2.0%	0.5 to 3.5%
FPI, with progress payments	1.0%	0 to 2%
Cost-plus-incentive-fee	1.0%	0 to 2%
Cost-plus-fixed-fee	.5%	0 to 1%

For example, if an FFP contract with progress payments has a 15 percent fee, 3 percentage points are for contract risk. The value of the risk transfer (as indicated by the DFARS "profit" rules) associated with an FPIF contract vice an FFP contract is 1 percent.[7] Note that the rules make no distinction between an FPIF with a high share ratio (e.g., 80 percent of overruns/underruns absorbed by the government) and one with a low share ratio. However, the designated range allows the contracting officer some leeway in accounting for the different levels of risk transfer possible in an FPIF contract.

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Valuing EPA Risk Transfers Using Financial Models

The value of an EPA clause is what the finance literature calls the "risk premium"—the minimum price (or fee reduction) that the government might charge for taking the specific risk from a contractor.[8] The financial tools used to determine the market price of risk implied in hedging debt and commodities form the basis for valuing an EPA clause.

Keynes (1930, pp. 142–44) and Hicks (1946, pp. 146–47) were the first to develop theories on the returns associated with commodities futures markets. Their *normal backwardation* theory postulated that the risk premium would accrue, on average, to buyers of futures (analogous to the government for an EPA). This was due to producers (the contractor) selling futures—thereby hedging their profits—to speculators (the government), who required in return a price below the expected spot price at maturity (potential decrease in negotiated fee). This is similar to a hedger buying insurance from an insurance firm that serves as the speculator. The insurer expects that the premium includes compensation for administration and other management expenses associated with the insurance policy. These are all analogous to an EPA.

To apply this to valuing the cost of risk to the government associated with EPA clauses, consider two extremes: a contract that is exposed to general inflationary risks in all elements of cost, e.g., labor and materials, and a contract exposed exclusively to risk in its commodity costs. In the first case, the entire contract is exposed to general inflation and the risk that this inflation deviates from the forecasted inflation used in developing the contract. The risk that, overall, all inflation deviates from forecasted inflation is called the Inflation Risk Premium (IRP). In this case, if the government were to charge a risk premium to hedge

the contractor from the entire amount of this risk, it could be estimated directly as the IRP. This premium would be reflected as a reduction of the fee paid to the contractor.

To understand the IRP, begin by examining risk premium generically. A risk premium is the discount required on an investment whose cash flows are subject to fluctuations in value due to its exposure to a particular risk. The price discount is computed as the price relative to the same asset that is free of the risk exposure. For example, the equity risk premium, as used in the capital asset pricing model, is the discount investors require on an investment in the market portfolio of equity securities relative to the risk-free rate. For U.S. stocks, this can be estimated by calculating the rate of return implied by the Standard & Poor's 500 index over 10 years and subtracting the yield on the 10-year Treasury Note.

The value of an EPA clause is what the finance literature calls the "risk premium"—the minimum price (or fee reduction) that the government might charge for taking the specific risk from a contractor.

This equity risk premium example is merely an illustration of the purpose of a risk premium. An EPA clause is designed to target very specific risks, in most cases inflation. Fortunately, this type of risk can be decoupled from certain types of publicly traded debt instruments. For a fixed rate note, the value of the interest payments is eroded should the rate of inflation exceed the rate that was assumed when the note was originally issued.[9] The IRP compensates investors for bearing the risk of inflation.

The other extreme case is when the risk is due to exposure to price volatility of specific commodities, only a fraction of the overall cost of the contract value is at risk. In this case, if the government hedges the contractor from commodity price inflation, the value of the risk premium is more like that embedded in the related commodities futures market—if one exists—in which commodities producers hedge price risk by selling futures contracts. Commodities make up only a small fraction of the cost of major defense acquisition programs. Even with the largest historical price swings for such commodities as titanium or nickel, the overall cost

of the contract is unlikely to change by more than 1 percentage point (Arnold, Patel, & Harmon, 2011; Tran-Le & Thompson, 2005). While a risk premium based on specific commodities can be estimated, it may be the case that such an EPA would not justify the cost of its implementation and management effort.[10]

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The U.S. Government raises debt through two main offerings: U.S. Treasury securities, which pay nominal interest rates, and Treasury inflation-protected securities (TIPS), which pay "real rates."

An EPA clause is most likely to be used in situations between these two extremes where most of the input price volatility is correlated with volatility in the overall inflation rate.[11] In these cases, one approach is to begin with the IRP and adjust it for the fraction of total contract cost represented by the inputs covered by the EPA clause.

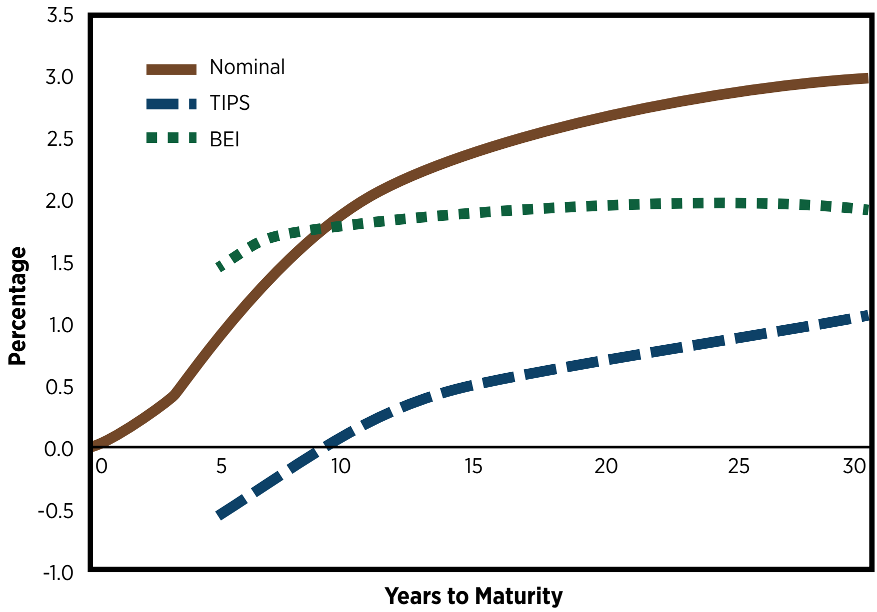
The U.S. IRP can be estimated by analyzing U.S. Treasury securities along with a consistent inflation forecast.[12] The U.S. Government raises debt through two main offerings: U.S. Treasury securities, which pay nominal interest rates, and Treasury inflation-protected securities (TIPS), which pay "real rates." The *term structure* of interest reflects the set of yields on fixed interest rate notes maturing in the future. Comparing the effective yield of U.S. Treasury notes against their maturity date shows the term structure that reflects the market's expectation of future interest rates. When the economy is expected to grow, the curve is usually upward-sloping. The market's expected inflation—inferred from price forecasts, commodity futures, and other economic data—is also embedded in this term structure. The Figure shows the yield curve for nominal Treasury securities and TIPS from September 26, 2011 (Board of Governors, 2011).

The difference between the yields on similarly maturing nominal Treasury securities and TIPS is the "break even" inflation (BEI) rate. The BEI rate can be deconstructed into the expected inflation rate and the IRP, as follows:

Break Even Rate = IRP + Expected Inflation

The inflation-protected and nominal Treasury securities parallel the pricing of contracts with and without an EPA (linked to general inflation), respectively. The government saves the IRP by providing inflation risk protection; alternatively, the IRP is the cost of paying nominal rates. The government implicitly charges TIPS investors this premium relative to the buyers of nominal Treasuries. In similar fashion, an FFP contract with an EPA (linked to general inflation) is like providing inflation protection and the value of this IRP.

FIGURE. NOMINAL TREASURY AND TIPS YIELD CURVE WITH BREAK EVEN INFLATION RATE



Note. Adapted from "Selected Interest Rates – H. 15: Daily Updates" by Board of Governors of the Federal Reserve System (U.S.) (September 26, 2011). Retrieved from http://www.federalreserve.gov/releases/h15/update/

Application

The process of applying this to a procurement contract starts with a clear identification of what input is being covered and whether the contracting officer can identify a good market index or price series. Next, the overall effect of the commodity's price volatility on the contract cost must be estimated. Large price fluctuations for inputs such as titanium in the F-35 have a relatively insignificant effect on the overall cost of the contract, because they represent a small fraction of the cost. On the other hand, even mild fluctuations to general inflation can affect all of the contract's inputs, leading to relatively large cost changes.

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Although the IRP concept is relatively simple, computing an estimate from interest rate data can be a relatively complicated task.[13] It has been done using time series analyses of interest rate data and both historical and forecast inflation rates (Grishchenko & Huang, 2008). The IRP can also be estimated from prices for fixed income securities other than Treasuries.

The risk exposure from materials and other specialty commodities' price volatility may be too small to merit an EPA clause.

Examples of IRP estimates show that the premium varies over time. Inflation volatility is not stationary, and the IRP varies with economic uncertainty and expectations of high or low inflation.[14] Recent estimates of the IRP show it as low during periods of low inflation expectations and high during periods of high uncertainty. Shiller and Campbell (1996) estimated the IRP to be between 50 and 100 basis points by analyzing nominal 5-year Treasury yields over the period 1953 to 1994.[15] More recently, Durham (2006) of the Federal Reserve reported the IRP ranging from 15 to 120 basis points over the period from late 2000 to 2005. Grishchenko and Huang (2008) reported a smaller IRP—2 to 63 basis points—from their vector autoregression analysis of TIPS prices. A more recent staff report by Adrian and Wu (2009) of the Federal Reserve points to a higher IRP ranging from around 40 to over 250 basis points.

As stated earlier, the risk exposure from materials and other specialty commodities' price volatility may be too small to merit an EPA clause. One exception to this could be a contract for a product or service for which commodities such as food services or fuel were a high fraction of the cost. The commodities risk premium is typically higher than the IRP. Estimates from commodities futures data find the premium is similar to that for equities—about 4 to 5 percent. This premium was estimated by Fama and French (1987), among others (Gorton & Rouwenhorst, 2005; Basu & Miffre, 2011), using an equally weighted portfolio of commodities.

One way to deal with this would be for an FFP contract with an EPA clause to have a fee decrement of 50 basis points relative to an FFP contract without the clause, reflecting the IRP estimates for the present period of low inflation risk. The fee decrement could be adjusted by the cost share ratio if the contract type was an FPIF. This fee adjustment reflects the cost of bearing the risk that input prices could differ from expectations. The contract should already reflect the expected inflation rate so that the bearer of the risk exposure can reasonably expect to get the same degree of good news versus bad news.

Other Considerations

Other issues of risk and cost arise from the inclusion of an EPA clause in a contract. For example, effort required to manage the clause once the contract is executed carries an additional administrative cost. Also, the government faces a number of risks, discussed previously in the background section, by accepting the clause. These risks are closely related to the concept of an EPA clause as insurance. The risks include the basis risk associated with the indexes used; other risks can be related to risks inherent in any insurance: adverse selection (contractors with higher inflation risk opting into an EPA) and, to some extent, moral hazard (the contractor having an incentive to change its behavior to manipulate the EPA).

In addition to adjusting the contract fee by the IRP, the government should also consider managing basis, adverse selection, and moral hazard risks the way insurance companies deal with these risks. The government should evaluate its level of understanding of the contractor's costs and its incentives given an EPA clause. If the government deems itself at a significant informational disadvantage, it may need to apply insurance-like provisions to its contracts to share risks. One common insurance practice is coinsurance—only insuring a fraction of the loss exposure, perhaps 75 percent. A variation on coinsurance is a trigger band that is directed in the DFARS and is common in EPAs: The contractor is exposed to a narrow band of volatility—say ±3 percent—outside of which the government is fully exposed to the loss or gains.

Ultimately, assessing these other risks is idiosyncratic and requires an in-depth assessment of the specific contract and contractor. This is in contrast to the methodology described in this article to use market-derived risk premiums to price specific, but not supplier, idiosyncratic risks.

Discussion

An EPA clause transfers risk from the contractor to the government; in essence, it constitutes an insurance contract. EPA clauses, therefore, provide value to the contractor and cost to the government, and the government could take this into account in determining contract price. Setting the target fee used to establish contract price provides an opportunity to account for the value of an EPA clause, and the DFARS Weighted Guidelines now provide contracting officers with some flexibility to do so. If the government wanted to account for the value of the risk transfer systematically, it could develop adjustment factors for inclusion in the weighted guidelines.

The IRP, which is based on the Consumer Price Index (CPI), reflects a more diversified portfolio of goods than a typical EPA clause linked to a single commodity such as steel. Further study could also be performed to gauge the risk exposure of the various contract elements for which the government is willing to allow EPA clauses. Simplicity in constructing these clauses is important, and it may be that a single risk premium is sufficient to equitably price the EPA clause. To develop systematic guidelines, the government would have to consider adjustments to the EPA fee decrement to reflect changes in the IRP during periods of very high inflation expectations. While the literature does provide estimates of the IRP, a consistently applied method, possibly based on TIPS and nominal notes, might provide an effective pricing tool that captures changing inflation trends.

It is important to remember that the IRP will not keep the government from paying inflation adjustments associated with an EPA clause; rather, compensation to the government for bearing the volatility risk may drive the adjustments. Furthermore, the fee adjustment concept outlined herein does not consider the premium for bearing other risks associated with EPAs, namely basis risk, adverse selection, or moral hazard.

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Endnotes

1. In the FAR and DFARS, fixed price contracts (encompassing contacts that would otherwise be FFP or FPIF) with an EPA clause are considered a unique contract type. Thus, guidance regarding the EPA clause is included in sections describing contract types, specifically, FAR part 16 and DFARS subpart 216.
2. This article uses the term fee to refer to the difference between the contract price and the underlying cost of the contract to the contractor. This is to reflect the distinction with contractor economic or accounting profit, which is unlikely to be identical to the negotiated fee. The concept of fee here is referred to as profit in DFARS subpart 215.4.
3. Section 215.404-71-3 of the DFARS titled "Contract type risk and working capital adjustment" provides guidance on pricing contract type risk. If an EPA clause is included under the contract type category "Fixed-price with redetermination provision," the guidance is to set the fee as if it were a fixed-price incentive contract with below normal conditions. If, without the EPA clause, the contract would be priced as an FFP contract with a "normal fee" for contract risk of 3 percent, then this means that adding an EPA would reduce the fee to less than 1 percent. This fee adjustment may be reasonable for fixed-price contracts with prospective price redetermination (FP-PPR) where the price of the entire item being purchased could be adjusted upward in the future. However, for an FFP contract with an EPA, this could be a severe fee reduction if the clause references direct labor or materials that could be small fractions of the overall contract value.
4. In the finance and economics literature, this is referred to as "adverse selection" and is addressed later in our article.
5. Although there was no evidence of manipulation in this case, using an index driven by a contractor's own labor rates opens the possibility of increasing enterprise-wide profits though cost-shifting.
6. For government contracts, the tools for pricing FAR part 15 contracts are limited to percentage-of-contract-cost fee guidelines that outline the amount that should be paid as a function of the level of cost risk and management effort to which the contractor is exposed.
7. The fee difference between FFP and FPIF contracts could also partially reflect the greater level of government management effort required for an FPIF contract.
8. There may be other costs associated with the EPA that the government may seek to recover from the contractor. For example, there could be recompensable costs associated with administering the EPA. In this article, we are restricted to examining the cost of quantifiable risk.
9. Inflation is not the only economic factor that can erode the value of a bond; other factors are credit risk and the risk that market interest rates may rise.
10. Note that titanium may be vulnerable to potential gaming as the majority of domestic titanium metal is used in aerospace applications (DoDIG, 2009).
11. The expected inflation rates for contract inputs should already be reflected in the contract price excluding the EPA.

12. Alternatively, if the general forecast is believed to be not significantly different from the recent past, the IRP could be estimated from historical U.S. Treasuries and Consumer Price Index data.
13. For example, Adrian and Wu (2009) use a Kalman filter to estimate the parameters of a generalized autoregressive conditional heteroskedasticity model (GARCH) of the inflation rate risk premium.
14. Adrian and Wu (2009) found the IRP was strongly correlated with the equity Chicago Board Options Exchange Volatility Index or VIX.
15. Shiller and Campbell (1996) also estimated that the option value of inflation protection was about 140 basis points.

Keywords: *Fast, Inexpensive, Simple, Tiny (FIST); Program Management; Heuristics; Innovation; Oversight*

Current Barriers to Successful Implementation of FIST Principles

Capt Brandon Keller, USAF, and Lt Col J. Robert Wirthlin, USAF

The Fast, Inexpensive, Simple, and Tiny (FIST) framework proposes a broad set of organizational values, but provides limited guidance on practical implementation. Implementing FIST principles requires clarifying the definitions of "fast," "inexpensive," and "simple," recognizing where FIST does and does not apply. Additionally, a subset of the FIST heuristics was expanded upon to increase their usefulness for practitioners. The primary research findings are that FIST principles are less conducive for highly complex or novel systems, immature technologies, future needs, acquisitions in early development phases, or when performance is the foremost value. FIST principles were also found to be constrained by the acquisition process, the requirements process, and oversight.

Image designed by Diane Fleischer »


FAST
INEXPENSIVE
SIMPLE
FIST
TINY
TINY

The Fast, Inexpensive, Simple, and Tiny (FIST) articles first appeared in the Defense Acquisition University (DAU)'s *Program Manager,* a periodical later renamed *Defense AT&L* in January 2004 (Ward, Quaid, & Mounce, 2008). The articles were evaluated, iterated, and compiled into a cohesive thesis by Air Force Lt Col Dan Ward (2009) in "The Effect of Values on System Development Project Outcomes." To this day, Ward's theories and adept writing style have stimulated significant debate in the Department of Defense (DoD) acquisition community and academia. The FIST framework proposes a broad set of organizational values, but provides limited guidance on practical implementation. Implementing FIST principles requires clarifying the definitions of "fast," "inexpensive," and "simple," recognizing where FIST does and does not apply, and offering additional FIST heuristics based on the recommendations provided herein, to increase their usefulness for practitioners.

The purpose of this article is neither to discredit nor to aggrandize FIST. The intent is to impartially evaluate FIST concepts to increase knowledge and understanding.

FIST Principles

Ward mentions in his various writings, the "tiny" aspect is an "inescapable outcome" of accomplishing the first three (Ward & Quaid, 2006a, p. 31); therefore, the focus will be on the fast, inexpensive, and simple tenets of the FIST framework. These tenets should also be thought of as a single idea rather than a value set having separate parts. As a single entity, "an attempt to remove some portion of this value set is likely to impact the program manager's ability to implement any of it at all" (Ward, 2009, p. 8). Therefore, *all* the FIST principles must be present for a program to succeed. For example, the Bazooka is a success story because the program (and product) was simple *and* inexpensive *and* fast (therefore tiny as well). It adhered to all of the FIST principles.

Scoping "Fast"

One principle to delivering systems quickly is to get early and iterative feedback from users (Hebert, 2011). The assertion that early feedback from users leads to rapid development and shorter timeframes is accurate (Ward, 2004), but the limitations should also be discussed. Is it possible to get early user feedback on a Naval carrier? What about early operator feedback on a satellite program? This is nearly impossible unless a satellite or prototype is launched solely for this reason, which is often cost-prohibitive. Historically, around 80 percent of a space system's life-cycle cost is consumed prior to operations (Hebert, 2011). Therefore, operator feedback is often delayed until the system is fielded because launching a satellite solely for testing and user feedback is cost-prohibitive. To be fair, operator prototypes and simulators obtain a degree of operator feedback. This reduces the risk, but rarely is actual operator feedback with operational assets obtained in the space domain.

The "fast" aspect of the FIST framework also has a fair amount of overlap with rapid acquisitions. Rapid acquisition requires stable requirements (Ford, Colburn, & Morris, 2012). As requirements are usually not fully stable prior to Milestone B for major programs, FIST must be scoped to a certain phase in the acquisition system. The earliest phase for FIST implementation would likely be the Engineering and Manufacturing Development phase (post-Milestone B approval), because a Capability Development Document will be complete with all technologies at a Technology Readiness Level of 6 or greater.

For these reasons, FIST is less conducive in the early phases (pre-Milestone B) of the acquisition process, and therefore is less beneficial for delivering future needs. FIST is also less conducive for complex, large programs in which early operator feedback is not feasible.

Scoping "Inexpensive"

Ward suggests several times that large budgets hinder communication with the user community (Ward, 2004). Real feedback from users is extremely important, as Ward would agree, but no evidence is offered as to why this cannot be done with high-dollar programs. One theory is that high-dollar programs are generally for the complex, highly integrated, and interrelated systems. These systems tend to have a variety of users and stakeholders whose exact roles can be vague or undefined. For example, who is the user of an F-22? If the sole answer is the pilot, we are limiting our decisions to one of many users. A "user" with real combat feedback beneficial to acquirers includes air liaison officers, aircraft maintainers, air traffic controllers, instructor pilots, and the training schools, to name a few. Whenever these users have conflicting feedback and desires for the system, the program office must make engineering trade-off decisions. If users have conflicting desires, a subset of users will inevitably be unsatisfied and may view the program office as unresponsive if their desires were not met.

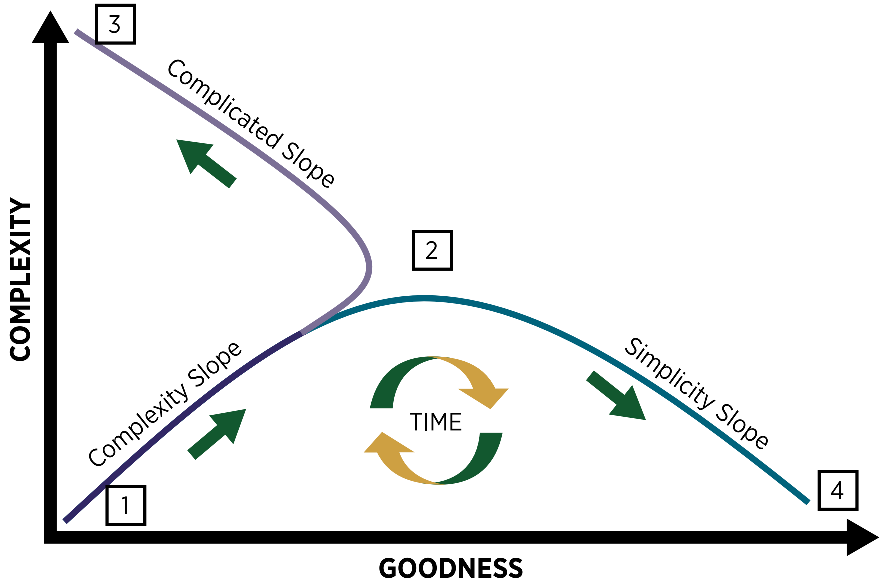
Therefore, large budgets are not the root cause of communication issues with users. Large budgets usually accompany complex, major weapons systems, which have various users and stakeholders with differing values. Consequently, FIST is less conducive for systems in which many users and stakeholders exist.

Scoping "Simple"

Figure 1 is the graphical representation of Ward's Simplicity Cycle. The graph depicts a certain turning point (shown by a "2" on the graph) in which adding complexity decreases "goodness" (ability of a system to do what it's supposed to do).

Understandably, at a certain turning point, adding complexity to a system actually decreases its "goodness." However, how do we know where this turning point is? Program managers and engineers do not add unnecessary complexity to systems without reason. "An inadequate appreciation for simplicity can result in an overvalued perspective of

FIGURE 1. THE SIMPLICITY CYCLE (WARD, 2005)



complexity, which can cause programmatic disaster" (Ward, 2005, p. 20). The opposite is also true, which causes another set of conflicting values. Holding to simplicity because the genius behind the complexity is not understood can also cause programmatic disaster. This concept is better understood with an example.

Holding to simplicity because the genius behind the complexity is not understood can also cause programmatic disaster.

Consider a team meeting to decide if solar retroreflectors are required on the exterior of a space plane. The viewpoint of the chief engineer is that they add complexity, cost too much, and will extend the program schedule. The materials expert contends that the retroreflectors are required because the sun's rays will burn the exterior before the payload will reach the proper orbit. Which to choose? One cannot blindly say that the retroreflectors go against all four FIST principles and, therefore, should not be pursued. FIST principles must be tempered with mission assurance.

As a result, the FIST principle of "simple" is less conducive for programs and technologies that are complicated and not well understood. One way to utilize FIST principles in immature or uncertain programmatic environments is to budget and plan for a simple, fast prototype. By doing this, much of the uncertainty and technical risk is reduced, removing these barriers to successful FIST implementation. The majority of uncertainty occurs in the early acquisition phases, so once again FIST is less applicable in the early phases of an acquisition. As Mathiassen and Munk-Madsen (1986, p. 20) state, "… in reality the [product development] situation is rarely well defined from the start."

One way to utilize FIST principles in immature or uncertain programmatic environments is to budget and plan for a simple, fast prototype.

Will a FIST Program Meet DoD Technical Guidance?

Current DoD technical regulations and guidance do not support FIST principles. This can be easily seen for programs that must comply with current DoD technical direction, such as the DoD Net-Centric Services Strategy or the Net Ready Key Performance Parameter (NR KPP) from Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 6212. The Net-Centric Services Strategy from 2007 promotes integrated systems employing net-centric principles, service-oriented architectures, and global information grid-compliant systems. This strategy ensures warfighters receive the right information at the right level of detail, from trusted and accurate sources, when and where it is needed (DoD, 2007). The NR KPP makes net-centric operations a KPP for all applicable systems (Chairman of the Joint Chiefs of Staff, 2012). These collaborative requirements are program-dependent, meaning they rely on other programs to comply with interface specifications before they can be compliant. Anything taking control away from the program manager goes against FIST because if PMs are dependent on external stakeholders, they will be less able to ensure speed and cost. Additionally, a graduate systems engineering certificate capstone project by Wong and Thompson (2006) cites the numerous cost and complexity issues related to technical interface management. Therefore, requirements mandated as part of the NR KPP are a current barrier to FIST implementation.

Of course the goal is to be compliant as fast and simply as possible, but complying with the NR KPP is neither a fast nor simple process. Once interoperability and net-centricity become better understood and operationalized, fast and simple concepts should be pursued to optimize performance in these areas. Therefore, if the system must comply with complex, undefined requirements (not all systems do), it will be more difficult to implement the FIST methodology. The point here is that Ward is absolutely correct that simplicity has many tangible benefits, but the thick waters of complexity must be waded through first, which many programs and technologies are still in the process of doing (most often in the complex, long-standing programs).

In summary, implementation of FIST principles is limited by DoD technical guidance. When guidance mandates compliance with technically complex requirements, achieving FIST principles is very difficult.

FIST is for Evolutionary (Not Revolutionary) Innovations

Ward states that "small teams + thin budgets + short timelines = significant innovation and combat effectiveness" (Ward, 2004, p. 34). This statement is true for today's fight; however, is it less applicable if the focus is on winning tomorrow's war? If the military simply has small teams with thin budgets delivering products and services quickly, we will lose the innovative edge with respect to our novel, complex systems. Some complexity is required, as the Simplicity Cycle states, before simplicity can be achieved.

Books on innovation and Lean principles describe the different strategies of "Invest in Evolution" versus "Invest in Revolution." Figure 2 maps common verbiage for similar concepts. The incremental improvement strategy is very similar to the FIST strategy. Both require a steady industrial base, mature technology, and the existence of a capability or performance gap in the current system. The risk to this strategy is that key new opportunities (radical innovations) go unexplored for incremental or evolutionary upgrades (Murman, 2002). Although incremental innovations sustain current capability, they don't produce the radical innovation necessary to address an asymmetric threat. This strategy does have value by delivering newer versions of existing systems faster. The DoD must be careful not to perpetuate existing monuments (in Lean speak), or not to let core capabilities become core rigidities.[1]

FIGURE 2. COMMON LEXICON FOR EVOLUTIONARY AND REVOLUTIONARY STRATEGIES

Strategy	Reference	Author	Year
Invest in Evolution	Lean Enterprise Value	Murman et al.	2002
= Directional ideas	The Medici Effect	Frans Johannson	2006
= Incremental innovation	Making Innovation Work	Davila et al.	2005
= Sustaining innovation	The Innovators DNA	Dyer et al.	2011
Invest in Revolution	Lean Enterprise Value	Murman et al.	2002
= Intersectional ideas	The Medici Effect	Frans Johannson	2006
= Breakthrough innovation	Making Innovation Work	Davila et al.	2005
= Disruptive innovation	The Innovators DNA	Dyer et al.	2011
= Radical innovation	Making Innovation Work	Davila et al.	2005

The opposite of an Invest in Evolution strategy is an Invest in Revolution strategy. The Invest in Revolution strategy involves game-changing innovations that result in current systems and technologies becoming obsolete. When a revolutionary innovation emerges, no further evolutionary upgrades are value-added. For example, the advent of electricity made upgrading candles (for practical lighting) obsolete. The advent of low-profile, stealth-like characteristics made many surface-to-air defenses obsolete. The downside of an Invest in Revolution strategy includes costliness, no guarantee a new capability will be fielded, and the risk of a gap in current capabilities (Murman, 2002). However, this is the primary strategy to take advantage of breakthrough technologies to remain a step ahead of the competition (Dyer, Gregersen, & Christensen, 2011). This is not trivial when the nation's defense is at stake. Herein lies the heart of a major barrier to successful implementation of FIST principles.

First, incremental improvements are normally completed faster, with less complexity (more simplicity) and at lower costs (Dyer, Gregersen, & Christensen, 2011; Johannson, 2006; Davila, Epstein, &

Shelton, 2006). Radical innovations are characterized by their novelty, technical immaturity, and mission uncertainty—all contrary to the FIST framework. Therefore, the FIST methodology closely aligns to incremental, vice disruptive, innovation. FIST success stories may not seem incremental based on the extent of the improvements. However, based on the fact that existing, mature technologies were used and the original platforms still have value, the improvements are, by definition, incremental. Although FIST principles have before and can continue to field radical innovations, these results are the exception. As Maier and Rechtin (2009, p. 405) state, "proven" and "state-of-the-art" are mutually exclusive properties.

Additionally, FIST enhances project stability (Ward, 2009). A corresponding limitation to project stability is the reduction of radical innovations. Radical innovation does not come from stable, secure, assured delivery environments. Rather, these game-changing innovations are born from organizations that embrace failure, are not risk-averse, and have a degree of instability as novel ideas are investigated.

When guidance mandates compliance with technically complex requirements, achieving FIST principles is very difficult.

Lastly, Ward agrees that a key to FIST implementation is the use of mature technologies (Ward, 2009), which is often the antithesis of innovation. A FIST program, as with a rapid acquisition program, does not have time to struggle with immature technologies. Unfortunately, many new weapon systems, especially space systems, are relying on immature and complex technologies (Government Accountability Office, 2006). This creates a barrier that must be overcome when trying to implement the fast and simple aspects of FIST.

For these reasons, FIST principles reduce radical innovations. Additionally, FIST principles are not conducive for immature technologies (as Ward would agree, citing mature technology as a key to FIST implementation).

Adding Realism to FIST

FIST is a set of guidelines, or heuristics, to help steer program managers to better decisions. However, many of the core aspects FIST urges program managers to embrace are simply out of the program manager's control. In these cases, research highlighting the lack of control and authority program managers have, especially in a Major Defense Acquisition Program (MDAP), in the current acquisition system is cited. A realistic set of guidelines for FIST must help program managers decide between available alternatives, not areas that are outside their control. One opportunity in which program managers can make engineering and programmatic trade-offs favoring FIST principles is early in a program, before the requirements, technologies, acquisition category level, and other decisions have been made more permanent. However, when program managers inherit programs later in development, many times implementation of FIST principles is out of their control.

4

"Simple" Realism

In terms of simplicity, a program manager is given a set of requirements validated by the Air Force Requirements Oversight Council and Joint Requirements Oversight Council, as required. Although a degree of requirements tailoring can be achieved through discussions between the acquirers and users, by and large the requirements have been vetted when the acquiring organization receives them. The requirements for complex, novel systems will consequently force the program office into complexity rather than simplicity.

Whenever and wherever possible, simplicity is an extremely valid heuristic to help manage a program.

In addition, the approval process and program oversight have been shown to be overly complex, very costly, and—to a large degree—outside the control of the program manager (Assessment Panel, 2006; Neal, 2004; Knue, 1991). Therefore, in the reality of complex, novel systems, not only does the required performance force complexity, but the acquisition process forces complexity as well. This is a barrier to implementing the FIST methodology, but should not be confused with

the fact that whenever and wherever possible, simplicity is an extremely valid heuristic to help manage a program. Current research investigates the applicability of rapid acquisition methods for traditional development programs with promising initial results. Ford et al. (2012) identify expedited systems engineering and rapid acquisition concepts that can potentially improve processes for traditional programs.

In summary, the requirements process reduces a program manager's ability to implement FIST principles. The acquisition process and oversight also constrain FIST implementation.

"Fast" and "Inexpensive" Realism

A program manager has a bit more control with respect to cost and schedule variables. Still, the acquisition process can have major effects on these as well, regardless of the program manager's intent. Ward highlights in "Putting the Pieces Together" that the common saying "better, faster, cheaper: pick two" is short-sighted and unjustifiable (Ward & Quaid, 2006a, p. 32). All program managers should desire better, faster, and cheaper each and every time. The problem lies in the DoD acquisition system, as the military reformers[2] found out while fighting tooth-and-nail to overcome it. A good example is the F-16 program as described in *The Pentagon Wars* (Burton, 1993). The development of the F-16 involved a bitter fight between the military reformers and existing senior leadership. The reformers wanted a cheap, focused air superiority fighter utilizing an existing airframe to reduce costs. At the time, military leadership lobbied for an all-purpose, air superiority aircraft with all the "bells and whistles." In the end, the F-16 emerged as a very capable, inexpensive, and quickly fielded aircraft (qualities the reformers valued). However, the program continually faced stringent resistance from the acquisition system and leadership. The normal acquisition processes had to be circumvented by nothing short of heroic efforts (Burton, 1993). Therefore, rather than trying to train heroes and ignore the root cause of the problem, the system should set the average program manager up for success. "Pick two" is forced upon program managers, and the following example will highlight how cost and schedule can quickly be taken out of the program manager's hands.

Program X is an MDAP approaching Milestone B with a cost estimate of $100 million. The Office of the Secretary of Defense Cost Assessment and Program Evaluation (CAPE) staff may disagree with the program office cost estimate when conducting their 80 percent

estimate. Therefore, to ensure a successful Milestone, the cost estimate is reconciled and increased to the CAPE's estimate. Subsequently, the budget approved at Milestone B will reflect this higher cost estimate. In this simplistic yet realistic example, the program office is *forced* into an increased budget. The same example holds true for schedule as well. A decision authority often regards a condensed schedule as unrealistic, and either increases the cost estimate to accomplish the condensed work, or forces the schedule (using independent schedule analyses, which tend to be more conservative) to expand. The key to passing a Milestone is to have a low-risk, high-confidence program in an executable cost within the budget. In other words, offering a strategy that's faster and cheaper than comparable programs is often viewed by oversight personnel as the program office staff not fully understanding the scope of the effort or overestimating a learning curve. In this case, the historical acquisition deficiencies work against the program offices' efforts to streamline and plan in efficiencies. Because of this, a "better, faster, cheaper" program may not receive Milestone approvals as the program is unlikely to be a highly confident, executable program.

4

The acquisition system limits the strategy to the Iron Triangle concept of cost, schedule, and scope (performance): pick two.

Ward states in his thesis that simultaneously improving cost, schedule, and performance without reducing complexity leads to failure. "Excessive complexity in the organization and the system virtually *requires* project leaders to improve only two sides of the "Program Manager's Iron Triangle," while simple organizations can produce simple technologies that are simultaneously faster, better and cheaper" (Ward, 2009, p. 87). We must temper this statement with the realization of what is acquired from simple organizations producing simple technologies: simple systems. As mentioned earlier, complex, traditional MDAPs do not meet this criteria.

Therefore, the "better, faster, cheaper" strategy is not practical. The acquisition system limits the strategy to the Iron Triangle concept of cost, schedule, and scope (performance): pick two. Additionally, few simple organizations producing simple technologies exist in the complex

business of defense acquisition. Program managers must actively manage the trade-offs between cost, schedule, and scope, and be cognizant of how altering one will inevitably alter at least one of the other pillars.

FIST Principles and Performance

Interestingly, the FIST framework does not include performance or quality, at least not in the acronym. Ward states that users must be satisfied with system performance to have value; however, the FIST framework does not foster high performance. In general, a product delivered quickly, cheaply, and simply will *not* perform as well as one with more time, money, and arguably more complexity. In developing a new iPhone, would a manager rather have 3 months and $100 thousand, or 6 months and $400 thousand? Logically, the performance of the more costly program should be greater. The exception is when acquiring known capabilities, in which acquiring them cheaper and quicker leads to the ability to acquire more, therefore increasing overall performance (think bombs and bullets). However, when discussing performance, requirements must be revisited. If the requirement is such that it can be met using FIST principles, by all means FIST should be adhered to. Defense acquisitions have, at times, lost sight of a requirement's underlying purpose and delivered gold-plated solutions (solutions with unnecessary functionality and capability). This is very important. If FIST principles allow a program manager to effectively meet a requirement, by all means the FIST methodology should be used.

For known capabilities, FIST principles are valid and should be valued more than gold-plating. For less known capabilities, minimal cost and minimal schedule should not be valued above performance, but effectively controlled and managed. As opposed to acquiring a known capability, "unknown-unknown" risks will surface during development that could not have been predicted. Managing a thin budget with no schedule slack for these unknown-unknowns is not smart management. FIST most certainly reduces unknown-unknown risks if the principles were followed during initial concept development and program initiation. However, applying FIST principles after program initiation would reduce the program's ability to handle uncertainty.

The FIST principles are not conducive for higher performance systems. Additionally, FIST principles, applied retroactively, limit a program's ability to mitigate unknown-unknown risks surfacing during development.

In review, Figure 3 compiles the FIST limitations discussed thus far. Now, a logical question would be: Can FIST be applied retroactively to programs already drowning in complexity? Additional research must be done to more thoroughly answer this question; however, it is generally believed that rapid and traditional programs are distinct in their requirements, goals, priorities, speed, and complexity. To this end, a recent Defense Science Board concluded that the Secretary of Defense should formalize a dual acquisition path separating rapid and deliberate acquisitions (Defense Science Board, 2009). In this case, FIST would be much more implementable in the realm of rapid acquisitions due to the limitations listed in Figure 3. Whenever the limitations listed in Figure 3 are not present in an acquisition, or if they can be influenced early during program conception, the FIST principles seem to be highly valuable and effective in meeting warfighter and taxpayer needs.

FIGURE 3. FIST LIMITATIONS

FIST is less conducive for:

- the early phases (pre-Milestone B) of the acquisition system
- complex, novel programs
- immature technologies
- radical innovations
- delivering future needs
- mitigating unknown-unknown risks

FIST is less conducive when:

- early operator feedback is not feasible
- multiple users and stakeholders exist
- performance is foremost value
- DoD technical guidance mandates complexity

Implementing FIST principles is constrained by:

- the acquisition process
- the requirements process
- oversight

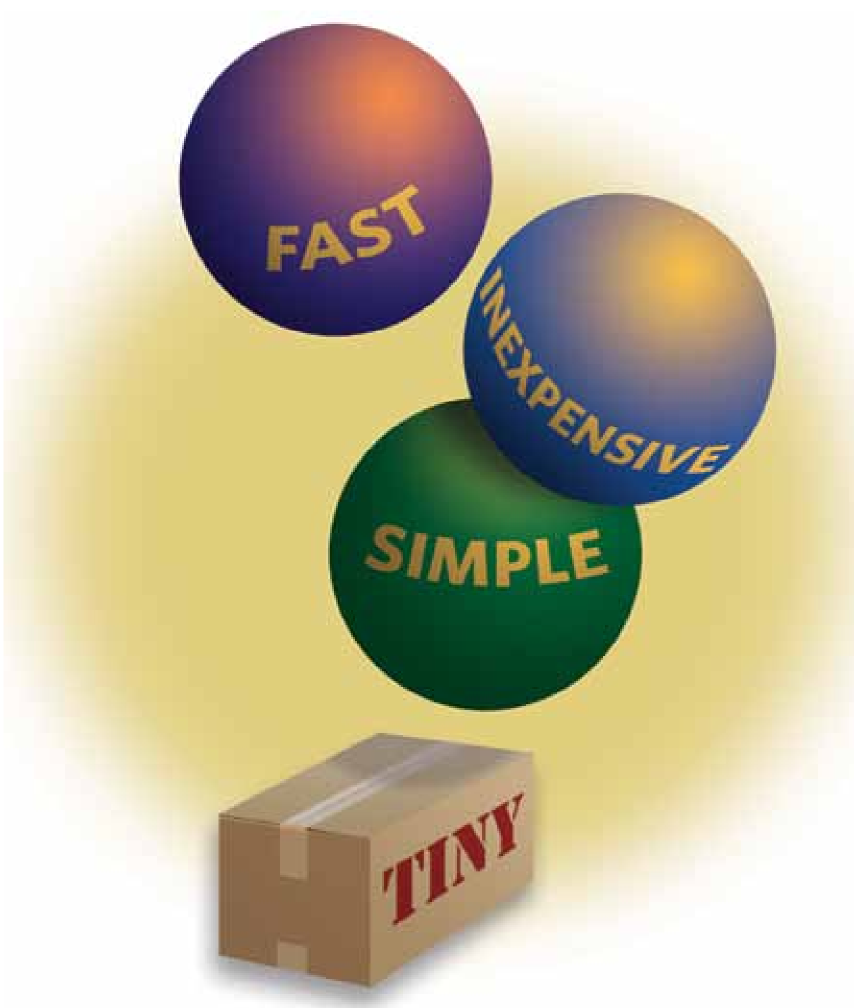
FIST as a Set of Heuristics

A heuristic is an aid to learning, discovery, or problem solving by experimental and trial-and-error methods (Heuristic, n.d.). Maier and Rechtin (2009, p. 29) provide a more useful definition in terms of product development, describing heuristics as a problem-solving approach “using guidelines, abstractions, and pragmatics generated by lessons learned from experience.” Heuristics can be considered the “art” side of the “art and science” of project management and/or systems engineering. The human test of a good heuristic is whether an experienced listener knows within seconds that it fits the domain it refers to and cannot be proven false (Maier & Rechtin, 2009). The value of a good set of heuristics, and the practitioner’s ability to know when they are applicable in different situations, should not be undervalued. The acronym for FIST in itself can be considered a set of heuristics:

- Deliver weapon systems as quickly as practical [**F**ast].
- Deliver at minimal expense [**I**nexpensive].
- Minimize design and system complexity [**S**imple].
- Minimize the size of products and processes [**T**iny].

Ward concludes his 2009 thesis with a list of FIST heuristics, clearly stating the importance of heuristics. Heuristics are particularly useful in program management because program management is not a hard science, but rather a social discipline (Dyer, Gregersen, & Christensen, 2011). The existing FIST heuristics are generally too broad or contradictory to be useful or actionable. Meaningful heuristics must be actionable to the maximum extent possible (Maier & Rechtin, 2009). For example, heuristic No. 3 from Ward’s thesis is: “The tortoise was faster than the hare.” Heuristic No. 6, however, is the opposite: “The best way to run a program is quickly” (Ward, 2009, p. 102). Opposite heuristics degrade usability. To render a heuristic more usable, the heuristic usually must be de-scoped and more directed to a particular topic. In other words, a heuristic that says, “optimally expending funds is vital to success” is much less useful than the more focused “rarely expend more than 90 percent of current fiscal year funds in the first half of the fiscal year.”

The FIST principles lend themselves well as a set of heuristics because each FIST term is relative. A tiny unmanned aerial vehicle and a tiny tank are not the same size. A complex fighter aircraft and a complex rocket launcher do not have the same complexity. These FIST concepts are, by their nature, relative terms that cannot be bounded for all situations. No checklist exists proving a system to be sufficiently simple, inexpensive, or fast. Therefore, describing FIST through a set of heuristics fits nicely because heuristics are generally agreed upon and cannot be proven false.



In reviewing the multitude of materials related to FIST and in light of the heuristics discussion, the authors offer here a review of the points made thus far as a set of heuristics, with the intent of increasing the set's usefulness for practitioners. As with all heuristics, we leave it to the community of scholars and practitioners to validate the efficacy of our recommended additions for themselves. Each grouping of heuristics relates to the FIST limitations highlighted in Figure 3 and previously discussed.

The following heuristics relate to the early phases of the acquisition system:

1. For the most relevant end product, start early.

2. To account for uncertainty, start early (Defense Acquisitions, 2010).

3. Without flexible requirements, unconstrained schedule analysis should be completed before accepting a constrained schedule.

The following heuristics relate to complex or novel programs:

1. Complexity must first be understood, then minimized (Ward, 2005).

2. At a certain program turning point, increased complexity reduces system "goodness" (Ward, 2005).

3. Define reliability requirements, *then* minimize complexity to achieve these requirements (Ward, 2005).

4. Minimize complexity until the point when the cost or time required becomes more burdensome than the complexity itself.

The following heuristics relate to innovation and delivering future needs with immature technology:

1. Rapid development approaches involve the user much earlier (Ward, 2004).

2. Rigorous independent analyses hold much more weight than internal, program office analyses (for cost, schedule, and technical maturity in particular).

3. Overfunding leads to tinkering and restrains innovation (Ward, 2004).

The following heuristics relate to tailoring DoD technical guidance and processes to each particular system:

1. Tailor processes to specific systems (Blanchard & Fabrycky, 1998).

2. Ensure processes are tempered with rationalism (Naur, 1982).

3. Don't let a process force a bad decision (Mathiassen & Munk-Madsen, 1986).

4. Don't let a process hold up a good decision (Mathiassen & Munk-Madsen, 1986).

5. Utilizing simple or standard interfaces can help reduce complexity, in turn reducing development costs (Ford et al., 2012).

6. Utilize "It Depends" management – maximizing knowledge of the environment and situation at hand optimizes decision-making.

Lastly, the following heuristics relate to the overall DoD acquisition process, including the requirements process and oversight:

1. Employ simplicity in both acquisition processes and engineering development.

2. Contractors should be allowed to bid their expected schedules without fear of being labeled "nonresponsive" (Ward & Quaid, 2006b).

3. Pick three *from the beginning*, or else be prepared to pick three and get two (see "Adding Realism to FIST" section of this article, discussion on "*Fast*" and "*Inexpensive*").

4. The project leader's influence over the development is inversely proportional to the budget and schedule.

Conclusions

Acquisition professionals should carefully consider the current barriers to successful FIST implementation. Realism was added to several FIST concepts to impartially assess how the framework relates to current practice. Finally, Ward's heuristics were expanded upon to increase the usability for practitioners. Interestingly, the Air Force announced that its Next Generation Bomber will be managed under the auspices of the Rapid Capabilities Office (Reed, 2012). The outcome of this program will undoubtedly offer a variety of lessons learned. The degree of innovation, either evolutionary or revolutionary, will be of particular interest for the FIST debate.

Once again, the FIST framework is an excellent revival of what the military reformers started: thoughtful inquisition, unyielding drive for excellence, wariness of the trade-offs between complexity and simplicity, and the needs of warfighters over the needs of politicians and programs. However, barriers and limitations exist to successful implementation of FIST in all types of acquisition scenarios.

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Endnotes

1. "Core Capabilities and Core Rigidities" is the subject of a seminal paper by Leonard-Barton in her 1992 *Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development*.
2. A group of military and civilian analysts emerging in the 1980s opposed lengthy, high-technology, complex weapon systems.

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Keywords: *Equipment Reutilization, Supply, Surplus Property, Operations and Maintenance (O&M), Defense Logistics Agency Disposition Services (DDS), Materiel Management*

Defense Logistics Agency Disposition Services as a Supply Source: *A DoD-Wide Opportunity*

Capt Nate Leon, USMC, Capt Todd Paulson, USMC, and Geraldo Ferrer

The Defense Logistics Agency Disposition Services (DDS) provide centralized disposal management of excess and surplus military property. An important component of its mission is the *reutilization* of excess equipment within the military services to prevent wasteful purchases within the Department of Defense. This research analyzes the extent to which the U.S. Marine Corps (USMC) is implementing reutilization through DDS as a source of supply. The results and recommendations of this study will enable decision makers within the USMC and the Defense Logistics Agency to address institutional and systemic obstacles to maximize reutilization. Some of the lessons learned herein may be useful to all the military services, resulting in more value from their operations and maintenance budgets through reutilization.

Image designed by Diane Fleischer »

Adopting economical business practices in the Department of Defense (DoD) is a national priority. Media coverage of the federal debt debate in Congress and in the White House focuses much attention on the largest contributors to U.S. federal spending—and the DoD is one of them. A low-hanging fruit readily available for immediate DoD savings is equipment reutilization—the reuse or initial use of excess or surplus property to meet known or anticipated requirements. Reutilization already saves the DoD millions of dollars each year by enabling both internal and intra-Service transfer of excess supplies and equipment, thereby preventing unnecessary purchase of property for which a suitable substitute already exists. However, according to reports from the Government Accountability Office (GAO, 2005a; GAO, 2005b; GAO, 2006) and a Department of Defense Inspector General (DODIG, 2011) audit, the DoD can and should do much more to capitalize upon the economic benefits of reutilization.

Reutilization already saves the DoD millions of dollars each year by enabling both internal and intra-Service transfer of excess supplies and equipment, thereby preventing unnecessary purchase of property for which a suitable substitute already exists.

Within the U.S. Marine Corps (USMC), reutilization occurs at the headquarters level via intra-unit transfers of principal end items, and at the unit level through the use of Defense Logistics Agency Disposition Services (DDS) field sites. DDS is typically used by the USMC for requisitions of consumable supply items, repair parts, garrison furniture, clothing, and many other items.

In this study we show that, to prevent excess purchase of supplies and equipment, and to realize significant organizational savings that might release funds to be used in other critical areas, the USMC should expand use of DDS inventory to meet its current and anticipated requirements. The USMC must develop doctrine, standard operating procedures (SOPs), supply techniques, and automated systems with this objective. The USMC supply and logistics community must foster and reinforce the utilization of DDS as truly a first source of supply.

In the following section, we present the concerns raised inside and outside DoD regarding the practices and culture of DoD supply systems. We start by discussing reutilization in the USMC, the information technology (IT) interfaces within DDS and the USMC, and how they enable or hinder the use of DDS as a source of supply. Then, we discuss current attitudes, assumptions, and initiatives by USMC company-grade supply officers (O-2 and O-3) regarding equipment reutilization, as provided in anonymous feedback during the early stage of this study. This is followed by a brief discussion and recommendations for improvement. Although our discussion is focused on data collected from USMC sources, and the lessons herein are specific to the USMC, we believe that similar benefits could also be achieved by other military services.

Prior Concerns

The War on Terror that has driven DoD operations since September 11, 2001, has enjoyed much support from the U.S. Congress in the form of seemingly limitless financial outlays. A report by Vanguard Advisors (Del Mar, 2010) identified a "blank check of sorts" that occurred between 2001 and 2010 for DoD acquisition, bonuses, pay increases, medical care, and morale programs. Because of the warfighting focus during this period, significant efforts to transform DoD business practices and economize within the agency took a back seat to operational requirements.

However, the ongoing U.S. financial crisis that began in 2007 has reminded us of the importance to be good stewards of the taxpayer's money. In that vein, making the right choices in purchasing and recognizing the savings opportunities that do not compromise our operational requirements remain defense budget imperatives. We believe that reutilization of surplus property is one of these opportunities, as expressed by the GAO and other observers.

GAO Findings

The reutilization of DoD supplies and equipment continues to be a focus of the U.S. Congress (Hast & Warren, 2000; GAO, 2005a). The 2005 report identified $2.2 billion dollars in "substantial waste and inefficiency" (p. 4) because "new, unused, and excellent condition items were being transferred or donated outside of DoD, sold on the Internet for pennies on the dollar, or destroyed rather than being reutilized" (p. 4). The report also found that the DoD purchased at least $400 million of

identical commodities in Fiscal Years (FY) 2002 and 2003 instead of reutilizing excess items in like-new conditions available in DDS. GAO identified numerous examples of DoD equipment sales and donation of items that were later requisitioned by the DoD at full acquisition cost. A portion of the report (GAO, 2005a) reads:

> We [GAO] requisitioned at no charge a medical instrument chest, two power supplies, and two circuit cards. Although these items had an original DoD acquisition cost of $55,817, we paid only about $5 shipping cost to obtain them. (p. 4)
>
> We also purchased at minimal cost, over the Internet at govliquidation.com, tents, boots, gasoline burners (stove/heating units), a medical suction apparatus, and bandages and other medical supply items. Although the total reported acquisition cost for these items was $12,310, we paid a total of $1,466 to obtain them—about 12 cents on the dollar, including buyer's premium, tax, and shipping cost. (pp. 4–5)

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Moreover, the report offered 13 recommendations to DoD for improving reutilization, many of which the Defense Logistics Agency (DLA) already had underway or subsequently implemented. These recommendations fell under three major headings: Data Reliability, Physical Control of Property, and Commodity Inventory Systems. All of them are directed to DLA and/or DDS, with the exception of the fifth and sixth recommendations, which are directed at the military services. Table 1 displays the 13 recommendations (GAO, 2005a).

Recommendations 2 and 3 are concerned with data reliability, a problem that we uncovered in our conversations with USMC supply officers. Recommendations 5 and 6 highlighted the importance of the military services "to do their part" to help DDS succeed in their mission. The last three recommendations, focused on excess property in prime condition, would help uncover reutilization opportunities more easily than what is done today, possibly generating even more savings than we discuss in this article. Most important: We were able to observe in 2011 many of the same issues that were raised in the GAO (2005a) report.

TABLE 1. GOVERNMENT ACCOUNTABILITY OFFICE RECOMMENDATIONS EXTRACTED FROM REPORT NO. GAO-05-277 (2005)

1.	to waive the requirement to verify quantities on turn-ins under exempted conditions
2.	to assure that excess property receipts are verified and processed in an accurate and timely manner
3.	to develop a mechanism for linking prime vendor purchase transactions to National Stock Numbers (NSN) or other unique product identification
4.	to develop written guidance and formal training to assist personnel and military service turn-in generators in the proper assignment of condition codes
5.	to provide accurate excess property turn-in documentation, including proper assignment of condition codes and NSNs based on available guidance [directed to the Services]
6.	to establish appropriate accountability mechanisms, including supervision and monitoring, for assuring the reliability of turn-in documents [directed to the Services]
7.	to review excess property loss reports to identify systemic weaknesses
8.	to resolve identified uncorrected security weaknesses
9.	to identify the appropriate number and liquidation sales locations needed to handle the sales of excess DLA depot property
10.	to inspect liquidation contractor facilities and take immediate action to correct structural impairments and other deficiencies
11.	to consider available options and implement an interim process for identifying turn-ins of excess new, unused, and excellent condition items
12.	to coordinate on the identification of key data elements for identifying excess property that should be reutilized
13.	to include edit controls in Business Systems Modernization (BSM) system design that would reject a purchase transaction or generate an exception report when A-condition excess items are available, but are not selected for reutilization

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A Cultural Analysis

Reusing valuable assets is a practice not as common as desired. To institute it as standard practice, the supply organization must change. With similar concerns, Doane and Spencer (1997) conducted a cultural analysis of the acquisition system within the DoD. Their analysis shed light on how individuals in the DoD resisted process changes, in particular in its acquisition activities. They studied two major Navy and Air Force acquisition programs through the lens of mission and strategy, goals, means, measurement, and correction.

Doane & Spencer (1997) defined culture as:

> ... a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptations and internal integration, that has worked well enough to be considered valid, therefore, to be taught to new members as a correct way to perceive, think, and feel in relation to those problems. (p. 25)
>
> They found two prominent cultural obstacles to DoD acquisition reform:
>
> - Little incentive for the workforce to change. Most government employees believe there is little competition or threat to their organization's existence. Since the DoD operated without a profit and loss sheet, the workforce did not feel the pressure to meet the bottom line, or the need to take risks.
> - The acquisition system is risk-averse. The acquisition system has been quick to penalize employees who make mistakes or take risks (also discussed in Ferrer & Dew, 2010). The workforce is conservative, strict about following rules, and self-preservationists. They are accustomed to routine and ordinary work, and are skeptical of initiatives and major change.

According to the authors, aligning the culture of the organization with the philosophies of acquisition reform is critical to achieve true benefits. However, this is difficult within the DoD because "most incentives and motivations are not apparent for either government or industry" (Doane & Spencer, 1997, p. 84). Industry incentives and motivation seem

to be based on the same profit and loss theories that were present before acquisition reform. Concurrently, the only incentives for government employees are personal pride in their jobs and respect of their peers. However, due to the constant rotation of supervisors within the DoD, change is often difficult to achieve (Doane & Spencer, 1997). So what can be done to transform culture in pursuing better DoD business practices? The researchers recommended leadership that questions old assumptions and can overcome organizational inertia and apprehension.

Additionally, leaders in a changing organization must foster open lines of communication and cooperation among other leaders and the organization's members. They must be accountable for their actions and empower the members of the organization, allowing them to fail and question authority without fear of reprisal. This empowerment will allow for new perspectives that may encourage innovation and generate better business practices (Ferrer & Dew, 2010). Reutilization is a prime example that fits this situation: Given that it is an uncommon practice, the habit of acquiring used assets from DDS—rather than buying them brand new—would require a cultural change. This, in turn, would require the support of civilian and military leaders for a continued period of time until it coalesced into the SOP. However, if the new process is cumbersome, and if no organizational incentives are in place to change a process that is generally accepted, the typical supply professional is unlikely to seize and apply the reutilization opportunity to its full potential.

Analysis of USMC Reutilization Efforts

In this section, we analyze how current USMC reutilization activities compare to the acquisition practices in other military services. By analyzing actual requisitions processed by USMC supply activities in FY 2010 and 2011, we show the potential cost savings that could be achieved by an increased use of DDS as a source of supply.

Potential USMC Cost Savings Through Reutilization

To get a clearer picture of the potential cost savings that the USMC could realize through increased reutilization, we analyzed *all* Marine Corps NSN requisitions inducted during four, 2-week periods throughout FY 2010 and 2011. These requisitions alone do not show the full breadth of total USMC requisitions, and therefore cannot fully capture potential cost savings. We had to remove from our analysis many items that do not have an NSN or are assigned a "local NSN" generated by the supply management unit. Nonetheless, NSN requisitions exemplify the volume of requisition traffic conducted through the USMC's standard supply system. We chose specific dates to represent each of the seasons of the year to capture a wide breadth of demand patterns. The specific dates of analysis were:

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- November 8–22, 2010
- February 14–28, 2011
- April 4–18, 2011
- August 8–22, 2011

We compared the demand for all NSNs over the specified sample periods with on-hand DDS inventory for the same 2-week periods using data retrieved from the DDS Management Information Distribution and Access System. We extrapolated the information to project the cost savings that the USMC could have achieved if it had used on-hand and available DDS inventory, to the maximum extent possible, to fill its requisitions. We conducted this analysis for two sample groups. Group 1 included a cost savings roll-up for NSNs listed only in Supply Condition Code (SCC) A (like-new condition), while Group 2 consisted of a cost savings roll-up for NSNs listed in SCCs B and C (serviceable condition)

TABLE 2. POTENTIAL SAVINGS FOR DDS AS SOURCE OF SUPPLY (SCC A)

	Nov 8–22, 2010	Feb 14–28, 2011	Apr 4–18, 2011	Aug 8–22, 2011
Number of unique NSNs	196	193	284	857
Total Acquisition Value	$464,329	$1,465,013	$315,153	$1,104,550

Sources: DLA, USMC Logistics Command, the authors
Total potential savings for 8-week period: $3,349,045
Total potential annual savings: $21,768,793

Table 2 shows the results of our analysis of Group 1, and Table 3 shows the results of our analysis of Group 2, indicating the potential cost savings for each of the four, 2-week periods. We computed the total acquisition value in the tables by multiplying the quantity available at DDS for each unique NSN in the specified period, by the full acquisition price for the NSN. Extrapolating the 8-week data, we estimate a potential USMC annual cost savings of $21.8 million using SCC A, in addition to $6.7 million using SCC B items. Extrapolating further, we estimate that the full adoption of condition SCC A and B items from DDS could have provided savings of approximately $28.5 million for the USMC in FY 2011.

TABLE 3. POTENTIAL SAVINGS FOR DDS AS SOURCE OF SUPPLY (SCC B)

	Nov 8–22, 2010	Feb 14–28, 2011	Apr 4–18, 2011	Aug 8–22, 2011
Number of unique NSNs	66	104	2	143
Total Acquisition Value	$123,853	$194,053	$3,080	$708,296

Sources: DLA, USMC Logistics Command, the authors
Total potential savings for 8-week period: $1,029,282
Total potential annual savings: $6,690,333

Example of Potential DLA Disposition Services Use

In the previous section, we used the four sampled periods to describe how USMC requisitions represent a wide variety of supplies and equipment—from inexpensive repair parts to major pieces of equipment—all of which were available within the DDS inventory at no cost. To further isolate potential cost savings that the USMC could have achieved by utilizing DDS, Table 4 provides a snapshot of the two most expensive items (SCC A only) from each of the four sampled periods.

Using the USMC NSN requisition data from the four sampled periods, we compared the total quantities of requisitioned items with the total on-hand quantities available at DDS for the same NSNs, during the same ordering periods. This analysis allowed us to see what types of supplies had the greatest probability of being filled from DDS inventory. Table 5 shows some of the most requested supplies for each of the four sampled periods that were simultaneously available for issue within the DDS inventory. In this small sample, the total value of the requested items was $216.8 thousand, of which $188.4 thousand could be supplied by DDS—87 percent of the total. The large number of requisitions and the high level of availability are enough to warrant reutilization. This is especially true when most of these items are SCC A, like-new items.

Sales Through Government Liquidation

At the time of this writing, Government Liquidation (GL) was the privately contracted company used by DLA to sell excess DDS property to the public after the property has undergone the full Reutilization, Transfer and Donation (RTD) screening cycle. Sales are conducted using a Web-based auction format. According to the DLA, sales through GL generated a total of $31.4 million in FY 2009, and $29.6 million in FY 2010. We analyzed every sale of NSN items conducted by GL for FY 2010 using a list provided by DLA. We compared this list with the requisitions conducted by the USMC during the four sample periods previously described. Our goal was to identify cases in which the DLA sold supplies and equipment through GL for which the Marine Corps had a valid need in the same fiscal year. We found that 9,909 unique NSNs in SCC A were sold in FY 2010 through GL that were also requisitioned by the USMC during the four sampled periods. Although we could not determine whether these items were available at precisely the same time they were requisitioned, our findings nonetheless show that DLA is selling supplies to the public for which the USMC possesses a valid need and continues to order at full acquisition cost.

TABLE 4. LIST OF MOST EXPENSIVE REQUISITIONS FOR SAMPLE PERIOD (SCC A)

NSN	Nomenclature	Acquisition Value	Quantity Available	Potential Savings
1010012589638	Slip Ring, Twelve CH	$8,023	1	$8,023
6230012541666	Light Set, General Illu.	$14,048	1	$14,048
1385014569129	MK3MOD0	$193,058	1	$193,058
5855015387023	Pan and Tilt Assembly	$61,137	8	$489,096
2540015464267	Armor Set, Supplement.	$27,146	2	$54,292
2330011087367	Trailer, Tank	$12,955	1	$12,955
2530014841419	Wheel and Tire Assy.	$23,422	2	$46,844
8340014563637	Lightweight Maint. Encl.	$16,498	1	$16,498
TOTAL				**$834,814**

Sources: DLA, USMC Logistics Command, the authors

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TABLE 5. DLA DISPOSITION SERVICES SUPPLY AVAILABILITY FOR USMC REQUISITIONS (SCC A)

NSN	DDS Inventory	USMC Requisitions	Nomenclature	Unit Price
8465011150026	235	2032	Canteen, Water	$5.08
5660002701510	1139	1800	Post, Fence, Metal	$6.75
7105009350422	1063	1238	Cot, Folding	$70.06
8440005437779	2300	1193	Socks	$1.45
6515015217976	1133	852	Tourniquet, Non-pneumatic	$43.50
8465008600256	7503	500	Cover, Water Canteen	$5.85
8465011178699	460	498	Bag, Duffel	$22.90
5310012349416	3598	470	Washer, Flat	$0.01
2590015762424	329	274	Cutter, Cable, Vehicle Mounted	$14.28
1095015216087	477	263	Bayonet, Knife	$116.18
8465014783009	5010	240	Strap, Webbing	$6.62
8415012968878	424	186	Vest, Tactical Load Carrying	$48.68
8460006068366	320	158	Kit Bag, Flyer's	$28.98
7240000893827	74	154	Can, Military	$18.77
1005005506573	91	121	Case, Small Arms Cleaning Rod	$6.82
6220015164926	468	113	Light, Marker, Clearance	$9.63
6240000802012	112	96	Lamp, Incandescent	$0.25

Sources: DLA, USMC Logistics Command, the authors

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Comparison of USMC Reutilization With Other DoD Services

Savings from DoD equipment reutilization impacts each DoD Service's Operations and Maintenance (O&M) budget. O&M appropriations traditionally finance those items for which the utility is derived for a short period of time. They usually comprise expenses rather than investments. Examples of costs financed by O&M funds are travel, fuel, expenses of operational military forces, training and education, recruiting, depot maintenance, spare parts, and base operations support. O&M appropriations are normally available for obligation for one fiscal year and are budgeted using the annual funding policy. Equipment reutilization has the potential to save O&M funds that could then be reallocated to other uses.

We define *reutilization rate* as the acquisition value of reutilized equipment as a percentage of O&M funding. Table 6 compares the reutilization rates of each military service from FY 2008 to 2010. The table shows that the USMC had the lowest reutilization rates over the three fiscal years. Although O&M budgets in the other three Services increased between 7.8 percent and 9.6 percent, their reutilization expenses shrank -11.5 percent (Air Force), -27.2 percent (Army), and -33.0 percent (Navy),

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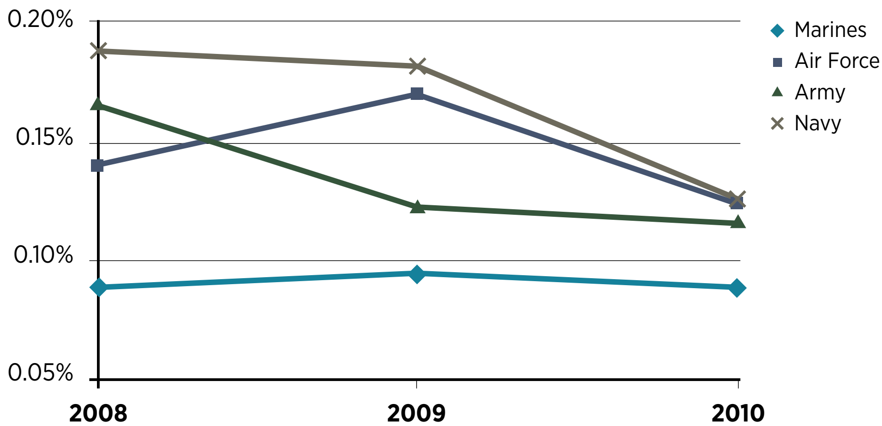
TABLE 6. DoD REUTILIZATION RATES (2008–2010)

Service	Fiscal Year	Operations & Maintenance Budget	Amount Reutilized	Reutilization Rate
Marines	2008	$9,256,100,000	$7,715,701	0.083%
	2009	$9,757,100,000	$9,022,663	0.092%
	2010	$10,327,300,000	$8,608,010	0.083%
Air Force	2008	$43,490,600,000	$61,250,572	0.141%
	2009	$45,388,500,000	$77,291,963	0.170%
	2010	$46,869,800,000	$54,194,481	0.116%
Army	2008	$82,838,400,000	$136,513,483	0.165%
	2009	$82,877,200,000	$104,777,760	0.126%
	2010	$90,793,300,000	$99,352,677	0.109%
Navy	2008	$39,923,200,000	$74,296,155	0.186%
	2009	$39,847,100,000	$73,495,085	0.184%
	2010	$43,129,600,000	$49,757,887	0.115%

Sources: DLA, Office of the Secretary of Defense, the authors

as shown in Figure 1. The Marine Corps was the only Service for which the reutilization expense kept pace with the O&M budget increase. However, the USMC reutilization rate was steady, but it was low compared to other Services. Considering the reutilization opportunity of $28.5 million, previously estimated, the USMC seizes approximately 30 percent of all excess property that matches its current needs each year. In the following sections, we discuss some reasons why the reutilization rates at the Marine Corps remain low, and offer some recommendations for improvement.

FIGURE 1. EVOLUTION OF REUTILIZATION IN DoD (2008–2010)



Summary of Requisition Analysis

We estimate that the potential annual savings for USMC adoption of DDS as a source of supply is $28.5 million in FY 2011. This amount represents the full acquisition value of supplies that were on-hand and ready-for-issue within the DDS inventory in the same year that USMC personnel requisitioned them. Rather than these orders being filled from DDS on-hand inventory, they were instead filled with brand new supplies and equipment from standard inventory control points and from prime vendors at full acquisition cost.

In some cases, filling non-DDS orders might be necessary because of the need for expedited delivery. The lead-time for DDS order fulfillment is longer than that of standard order fulfillment. Hence, supplies ordered with Force Activity Designator priority 3 or higher are better serviced from standard inventory control points. In the case of lower priority supplies with no requirement for expedited delivery, the DDS is invariably

the most cost-effective choice for requisition fulfillment. The following sections discuss some of the reasons why reutilization is not being used to its full potential.

Nonintegrated Systems Impair Reutilization

The GAO reported that supply management IT systems at DLA that enable integration are outdated and are not integrated with the supply systems used by the Services (GAO, 2005a). The DLA has IT initiatives underway to correct this deficiency; however, the integration of these efforts with the systems of all military services is critical. The following sections provide more detail on the legacy and emerging IT systems that will be key components in improved reutilization efforts.

USMC Standard Automated Materiel Management System

The legacy automated materiel management system for the Marine Corps is the Supported Activities Supply System (SASSY), which interfaces neither with DLA's Enterprise Business System (EBS) nor with the automated Digital Accessible Information System (DAISY) used by DDS. Instead, USMC supply transactions are first filled, if possible, at the supply management unit. If the unit does not have the item in stock, it passes the requisition to the Marine Corps Logistics Base Automated Information Systems Transaction Router (MAISTR). Such transactions are grouped at each unit and transmitted at the end of the working day. MAISTR then interfaces with the Defense Automated Address System, finally resulting in a requisition at the DLA that is screened by EBS, possibly ordered by the Distribution Standard System (DSS), and finally shipped to the customer. The entire process from requisition to delivery has a wait time of several days, depending upon customer priority and conditioned on item availability.

When the Marine Corps developed SASSY, it was not intended for supply chain integration with other DoD supply systems. Soon, SASSY and other legacy systems will be replaced by Global Combat Support System-Marine Corps (GCSS-MC), currently under implementation—a major DoD acquisition program that is aligned with other Services' Global Combat Support Systems. It seeks to seamlessly integrate with the DLA's inventory and asset visibility systems, providing real-time visibility to USMC customers. However, GCSS-MC does not improve upon SASSY's ability to screen DDS stock since it will not directly interface

with DAISY, the DDS inventory management system. Therefore, the GCSS-MC alone will not be the solution for reutilization efforts. The solution resides in DLA's ability to seamlessly integrate DAISY with its national system (EBS).

DLA Systems

Prior to the GAO's findings on outdated DLA systems in 2005, the DLA had begun an IT transformation effort known as Business Systems Modernization. As part of that effort, EBS was introduced in 2006. DAISY—fielded in 1990—is still in use and unable to communicate directly with the EBS. However, a current DLA initiative known as Reutilization Business Integration will integrate all DSS business processes within the DLA suite of business applications, by moving all data and functions from DAISY into the DLA's DSS and the EBS. Once this occurs, it may be possible to directly source supplies from DDS inventory in fulfillment of requisitions from all military services. The implications for improved reutilization will be profound, provided that DDS can be used as a source of supply with the same credibility and accuracy as current DoD suppliers. Figure 2 shows the current DLA systems construct.

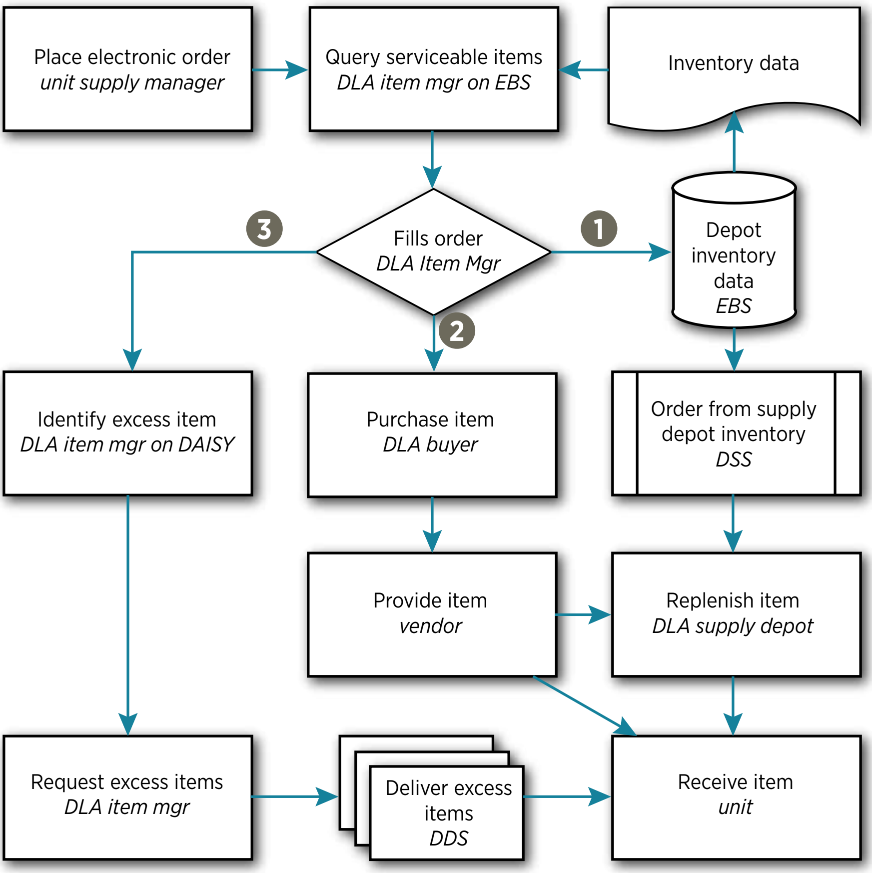
Organizational Climate for Reutilization at USMC

Before we started this study, we sought advice from approximately 300 Marine Corps company-grade supply officers on the types of data and reutilization topics we should explore. We e-mailed them using contact information available at the *Marine Online* personnel management Web site. Our goal was to use their various insights to help steer our research into the most relevant and timely areas. Although this outreach did not constitute a scientific survey or formal interview—responses were voluntary, anonymous, and used solely for background information to review the community's perception on reutilization—we nonetheless received some comments that were useful in our study.

Supply Officer Feedback

A total of 62 supply officers in the grades O-2 and O-3 provided general comments about their experiences using DDS as a source of supply, as well as their usage level and predominant method of DDS requisition. All respondents consented to anonymous citation in this report, summarized as follows.

FIGURE 2. REUTILIZATION USING DEFENSE LOGISTICS AGENCY IT SYSTEMS



Sources: DLA, the authors

Of the 62 respondents, 41 indicated that they had used DDS on at least one occasion to order supplies, while the remainder never used DDS for requisitions. The most common method for requisition was the RTD Web site, followed by a physical walk-in at an installation DDS field site. Most respondents who had used DDS as a source of supply were at least somewhat satisfied with the results, though some mentioned errors in the accuracy of SCC and item identification—a concern previously raised in Report No. GAO 05-277 (GAO, 2005a).

Of the respondents who did not use DDS as a source of supply, the most common reason was the lack of financial incentive to do so. They mentioned that their budgets were sufficiently large to procure new supplies at full cost.

The procedures to turn in excess, damaged, or obsolete property place heavy reliance on the person turning in equipment (known to DDS as the "generator") to ensure paperwork accuracy. However, the generators have little incentive to ensure 100 percent accuracy because the equipment will no longer be in their custody. DDS employees are often unable to provide a redundant check because of manpower constraints or lack of expertise concerning the property. The end result is that items often enter DAISY with an improper NSN, nomenclature, SCC, or demilitarization code (DLA, 2008).

These inaccurate inventory data were also mentioned in Report No. GAO 05-277 (GAO, 2005a), which cites "unreliable excess property inventory data" as a root cause for "billions of dollars in waste and inefficiency." According to Kutz' testimony (DoD Excess Property Systems, 2005), the DLA implemented several changes, including the consolidation of numerous field sites for better property control, changes to their

process, and the installment of a Senior Executive Service director to oversee the organization. However, our research shows that many USMC supply officers remain skeptical of inventory accuracy, based on their experience turning in equipment at a DDS site.

Finally, many supply officers did not use DDS because they were simply unaware of the RTD Web site to screen inventory nationally and internationally. Students at Marine Corps supply schools are trained to use the RTD Web site, but this training should be analyzed for uniformity, rigor, and skills retention. Moreover, occasional refreshers may be necessary. This resonates with GAO Recommendation No. 4 (Table 1). Although DDS does have some resources, they are not sufficient to ensure a broad reutilization of excess property in their possession by the Services that need them.

Discussion

We have shown that some of the reasons for not using DDS are that supply officers are frequently unaware of the benefits of using DDS, that they lack confidence in the DDS supply chain, or that the IT system is inconvenient, hindering frequent utilization. Based on the analysis of equipment reutilization with the USMC, we make some observations regarding the most notable characteristics of current reutilization efforts.

Many USMC supply community leaders are not aware of the breadth and utility of the DDS inventory as a source of supply, assuming most items to be "junk" and therefore ignoring the system. Although supply officers receive training on DDS screening at the Ground Supply Officers Course, this one-time class is not reinforced in the fleet, and may be easily forgotten. For this reason, many supply officers opt to use the standard supply system, the General Services Administration, and open purchases for all orders despite the availability of DDS inventory.

At the same time, USMC supply professionals may consider DDS, but typically do not trust it as a source of supply due to previous experiences with the cumbersome turn-in and reutilization processes or misunderstanding of the DDS fulfillment process; therefore, they ignore the system. Further, DLA and USMC distribution, requisition, and inventory management systems are not integrated, and therefore prohibit seamless requisitions of DDS supplies using the standard USMC supply system.

Consequently, DLA sells supplies and equipment to the public for which the USMC holds an ongoing requirement. The Marine Corps is not maximizing procurement of available DDS on-hand inventory, lagging behind the other Services, and annually forfeiting approximately $28.4 million in potential cost savings. We present a course of action that, if undertaken, will enable all military services to achieve substantial cost savings.

Recommendations

Until such time that GCSS-MC and DDS are seamlessly linked, the Marine Corps Deputy Commandant, Installations and Logistics, should establish Service policy in orders, directives, and SOP that requires screening available DDS inventory prior to inducting standard supply system requisitions, particularly Class II supplies. It should support these directives with incentives to the supply community to use DDS more frequently. This can be accomplished through performance appraisal and through an awards program for reutilization in conjunction with DLA.

Moreover, the USMC Logistics Command should maximize the untapped potential of the DoD EMALL, which provides on-hand visibility of DDS supplies in SCC A, by enabling USMC requisitions through Military Standard Requisitioning and Issue Procedures. For accountability purposes, such requisitions must be visible to the USMC Standard Accounting Budget and Reporting System.

DLA has a national marketing program to raise awareness for the potential of DDS reutilization for all military services. A key part of this program should be to conduct frequent training visits to supply activities of all Services to educate supply officers on the benefits of working with DLA Disposition Services.

DLA Disposition Services should establish a seamless interface between its automated information system (DAISY) and DLA's enterprise resource planning system (EBS), so that all requisitions placed via GCSS from any Service can be filled, to the maximum extent possible, by DDS on-hand inventory.

Finally, DDS must ensure 100 percent accuracy in inventory management data—most importantly the SCC, NSN, and quantity—so that all deliveries meet customer expectations. This reputation-establishment effort must begin at the property receipt process and continue through the entire reutilization cycle. If necessary, capacity at property receipt points should be overhauled so that DDS employees can effectively manage workload and ensure 100 percent accuracy in inventory management data.

We should not let inertia take control of business decisions. With sound leadership, we can start to pay attention to this opportunity to improve our expenditures and to do more while spending less. Nonetheless, seamless IT integration will be necessary before reutilization becomes common practice.

Author Biographies

Capt Nate Leon, USMC, is currently a ground supply officer in the Logistics Capabilities Center at Marine Corps Logistics Base in Albany, GA. He has 17 years of active service, 10 of which he served as an enlisted Marine. His career experience encompasses a wide range of operational and staff assignments, including a tenure as warfighting instructor at the U.S. Marine Corps Basic School in Quantico, VA. Capt Leon earned a BA in Political Science from University of Mississippi and an MBA from the Naval Postgraduate School.

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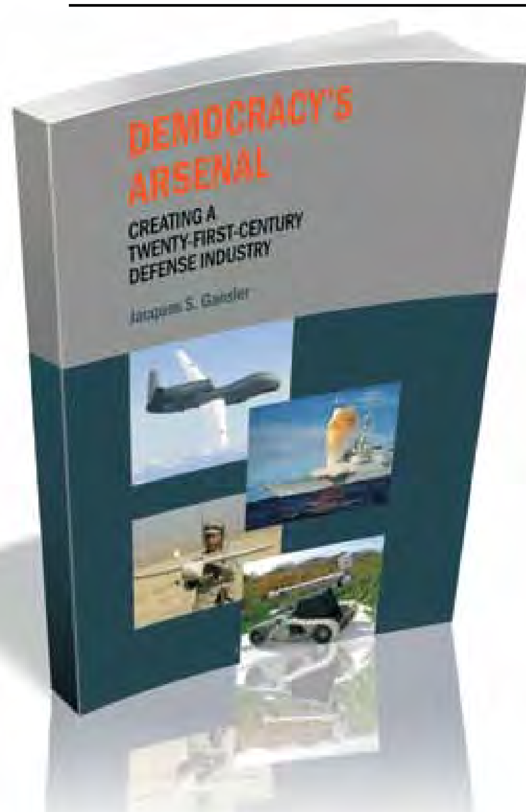

Featured Book

Democracy's Arsenal: Creating a Twenty-First-Century Defense Industry

Author(s):
Jacques S. Gansler

Publisher:
Massachusetts Institute of Technology Press

Copyright Date:
2011

ISBN:
978-0262072991

Hard/Softcover:
Hardcover, 432 pages

Reviewed by:
Professor Steven A. Jones,
Defense Systems Management College,
Defense Acquisition University

Book Review

Winston Churchill once said “You can always count on Americans to do the right thing—after they’ve tried everything else.” When it comes to our nation’s defense acquisition system, you would think Winston Churchill’s quote is spot on. Jacques Gansler describes in his book one more transformation needed in government and industry to achieve a new, more effective system of national defense. The author contends that this transformation is required if this country intends to meet all of the challenges to national security the new century brings. As suggested by the title, *Creating a Twenty-First-Century Defense Industry*, Gansler clearly outlines the changes he sees as essential in industry and the Department of Defense (DoD) business practices. He makes a compelling case for globalization of defense business and greatly reduced competition.

This is a well-researched and engaging book. Drawing upon his decade of experience in industry, government, and academia, Gansler argues that the old model of ever-increasing defense expenditures on largely outmoded weapons systems must be replaced by a strategy that combines a healthy economy, effective international relations, and a strong (but affordable) national security posture. The author describes many significant policy decisions made by the DoD over the last 30 years. He provides a significant bibliography to support policy decisions in the past and provides rationale for why these policies should change in the future. His extensive analysis provides the reader with detailed pros and cons of each hypothesis made and clearly articulates his conclusions.

One of the many “Globalization Thrusts” Gansler suggests is to increase purchases from foreign sources and to codevelop more weapons systems. He refutes those that claim this approach increases U.S. Forces’ vulnerability and contends globalization brings greater efficiency and innovation. He provides specific recommended changes in legislation to recognize this global defense market; he also claims this approach would establish a more appropriate, risk-based set of considerations associated with the vulnerability of U.S. Forces.

This book is of particular importance in today’s defense acquisition community as we approach a significant transition. It provides the reader with a vast knowledge of studies performed by DoD and

Congress that led to policy decisions and legislative actions in the past. Having this clear lens of hindsight is important to any decision maker in the DoD. This is especially important to Executive Coaches, providing a wealth of knowledge in the cache of tools available to coaches and their clients.

This book may spark a new twist to acquisition reform. Is it possible Winston Churchill is right? Have we tried everything else?

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